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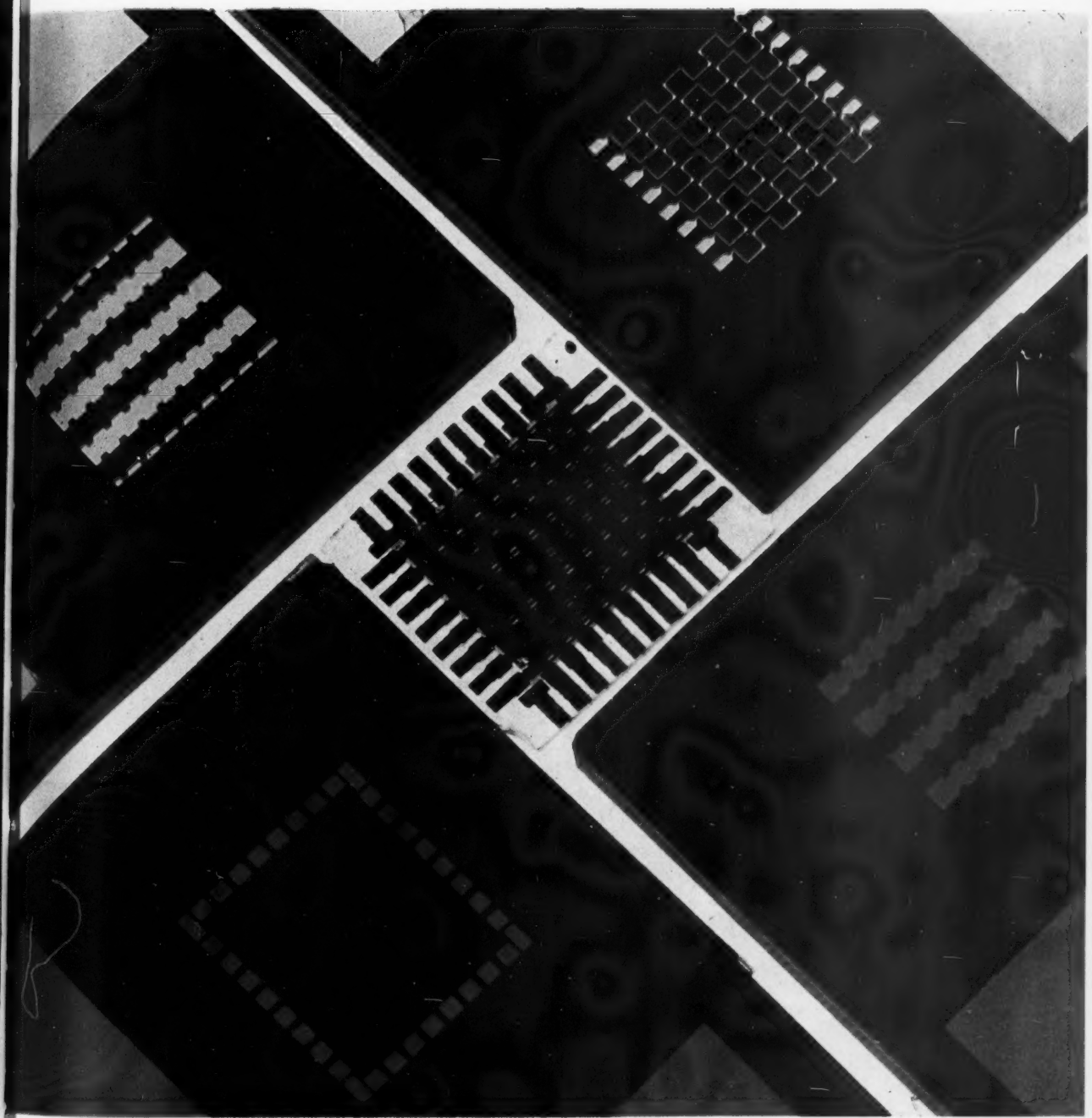
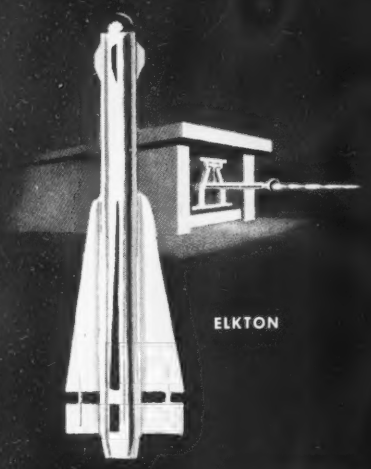
Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

MAY 1959



PAYLOADS AND MICROMINIATURIZATION



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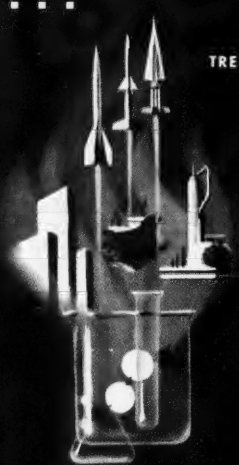

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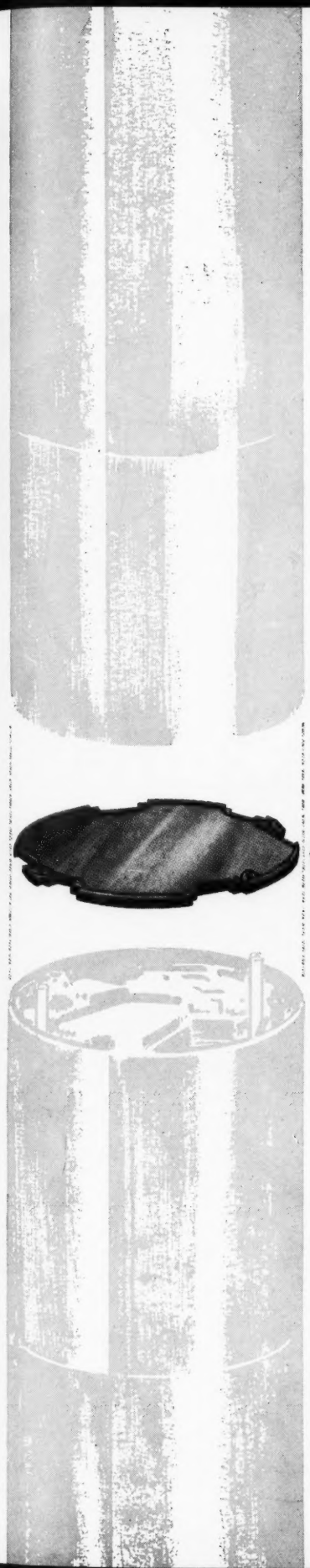

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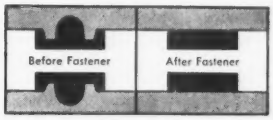

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Astro notes

MAN IN SPACE

• Models of the Mercury capsule have been put through a series of parachute-suspension, emergency-escape, and impact tests. Full-scale models were dropped from aircraft at high altitudes in studies of proper altitude for parachute actuation and motion during descent and impact. Small-scale models were launched on multi-stage rockets from Wallops Island to near orbital velocities to study aerodynamic heating during ascent and re-entry. Plans call for flight tests involving the full-scale capsule and rocket boosters from Cape Canaveral beginning in late summer.

• The seven volunteers selected by NASA as Project Mercury pilots will begin advanced training and participation in testing in the near future. The Space Flight Activity of Langley Research Center will be their home base. Seven, instead of the originally planned 12, were selected to allow each an important role in engineering development of the Mercury vehicle, suborbital missions, and final orbital flights.

• NASA has awarded Garrett Corp.'s AiResearch Div. the contract to supply the internal environmental control system for the Mercury capsule.

RANGES AND TRACKING

• A vast extension of the Pacific Missile Range may be imminent. The government is reportedly negotiating with Australia to obtain rights to a small island in the Admiralty Group as an equatorial launching site. Located north of New Guinea at a point only 2 deg south of the equator, the site would be ideal for easterly launchings of large payloads into equatorial orbits. Equatorial orbits are believed by many to be essential for large-scale manned space activities, which will require frequent rendezvous operations. Such orbits would vastly simplify the guidance task involved in bringing prefabricated assemblies and supplies to a single point in a satellite orbit.

• Combined DOD-NASA tracking facilities for satellites and space vehicles will include Goldstone-like stations with 85-ft parabolic antennas in Australia (Woomera), South Africa, and Spain, and a powerful station in Japan, besides the four new Minitrack stations in Alaska, the U.S. proper, Newfoundland, and Canada, and control stations in Hawaii, Texas, and Bermuda for the Mercury program.

• The new optical-tracking range set up on Long Island by some 50 volunteers of the Grumman Astronomical Society at Bethpage, RCA Labs at Rockey Point, and Custer Institute for Research at Southold, will operate on the same signals and use a method of triangulation to make precise measurements of satellite speeds and altitudes.

SPACE RESEARCH

• Discoverer II was launched into polar orbit from Vandenberg April 13 carrying a re-entry capsule which was to be snared in mid-air by aircraft as it fell over the Pacific Ocean near Hawaii. This high-flown fielding attempt was canceled, reportedly because of the failure of a timing device. The capsule was later ejected, however, and fell somewhere in the Arctic. The Air Force said Discoverer II will orbit more than a month.

• A Vanguard launched from Cape Canaveral the same day suffered a failure of the second-stage engine and did not orbit its payload—a 22.6-lb magnetic-field-measuring satellite and inflatable sphere.

• Preliminary study of the radiation data from Pioneer IV, which went into heliocentric orbit early in March, confirmed findings from Pioneer III. The tiny probe also telemetered evidence that high energy electrons from the sun feed the outer of the two radiation belts. Launched after five days of high solar activity, the probe discovered that radiation in the outer belt was two to ten times as intense as it was when explored by Pioneer III last December. The Van Allen counters aboard the probe also disclosed that the level of peak intensity of the outer shell had climbed in altitude—from 10,000 miles in December to 15,000 miles in March. These findings, plus an unexpected "raggedness" in counting rate as the probe coasted beyond the earth's magnetic field, indicated a replenishment of the outer shell had occurred and that the thin plasma was still in a turbulent state from solar bombardment.

• Explorer IV, although "off the air" since last September, still yields important data. An ingenious *post-mortem* conducted by two SUI scientists indicates the inner radiation belt definitely contains protons. This indicates the inner belt may be produced in part by neutron decay. The scientists noted a rhythmic waxing and waning in the counting rate of one of the satellite's shielded counters, and reasoned that this was related to the rotation and tumbling of the satellite in space. When the counter window was at right angles to the lines of magnetic force, the count jumped; when it faced in other directions, only high energy particles could enter. By correlating this data with an analysis of the radio signal from the satellite and the specific ionization produced by the charged particles in the chamber, they were able to show that protons form part of the radiation.

• Another first in rocket astronomy was scored by Richard Tousey and his colleagues of NRL. They obtained the first picture of the sun taken in the Lyman Alpha line of hydrogen. This line, located in the far ultraviolet, is absorbed by the atmosphere and cannot be detected by terrestrial instruments. But, by mounting a 35-lb spectrographic camera with diffraction gratings in the nose of an Aerobee-Hi and launching the assembly to 123-miles altitude, they were able to obtain a reasonably clear picture of solar activity in the Lyman Alpha wavelength. Besides broadening knowledge of high altitude events in the solar atmosphere, the new technique will be invaluable in studies of the solar corona and in the spectrographic search for undetected elements in the sun. Ultimately, NRL hopes to load its equipment aboard satellites for more leisurely studies of "hidden wavelengths."

• Because Vanguard II is wobbling slightly as it orbits, it may be months before Army Signal Labs unravels "tipsy" data on some quarter-million feet of taped signals and produces a picture of what the satellite saw of earth's cloud cover. ASL pinned down the angle of wobble necessary for deciphering the taped record with precise radio measurements.

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MILITARY SATELLITES

• The first of ARPA's Courier communications satellites will be launched into orbit late this year. A delayed repeater like the Score system carried in the Atlas satellite last December, the new system will have the equivalent of 20 continuously available channels and a capacity of 100 words per minute. It will be followed by real-time repeaters in higher orbits in 1960 and 1961, and in 1962 with the "ultimate" Courier—a large stabilized package in a 22,000-mile "stationary" orbit. The equatorial Courier will have 145 real-time relay channels, including one for aircraft use.

• A separate ARPA program aims at developing a satellite system for reliable communication between points in the U.S. and aircraft in the polar regions. First firing is expected in 1961, with an operational network of several satellites a year later.

• A simpler but grander satellite communications system will be put into operation by the Navy. Using the moon as a passive relay point, the Navy expects to put its first lunar bounce circuit into operation late this year between Washington and Pearl Harbor. The moon relay system should provide greater reliability and antijamming capability than conventional systems.

• The first tactical cloud-cover satellite is slated for launching in July or August, with another in February or March of 1960. These satellites, under construction by the Army Signal Corps, will be equipped with three cameras positioned at various angles which will feed pictures into separate magnetic tape recorders for playback when the satellite is interrogated by ground stations. The satellites will produce 1000 pictures every 24 hr, with each picture carrying its detail in 500 lines per millimeter—far superior to present television systems.

ARGUS

• Even though they stole a march on the Russians last year with the Project Argus nuclear blasts, Pentagon scientists still aren't satisfied. They want more information about the behavior of electrons and protons in the earth's magnetic field, and they believe bomb bursts are crucial to progress in this area. But, with the Administration determined to stick to the nuclear test ban, it appears that the scientists will have to look for other means to study the new effects. One possible substitute was proposed last August by S. F. Singer of the Univ. of Maryland. His idea: A klystron tube placed in a satellite to pour streams of energetic particles into the magnetic trap.

• Although the military aspects of the three Argus shots remain shrouded in heavy security, it's clear that the Pentagon was more interested in the effects of high altitude nuclear explosions on communications than in the use of the devices to neutralize hostile missile warheads by particle "screens." (The two Johnson Island blasts fired earlier were designed to investigate the anti-missile problem.)

• The use of Argus-type blasts to affect radio communications was illustrated by ARPA Director Roy Johnson, who confirmed that a large nuclear bomb detonated high over the Indian Ocean would black out all radio communications in the Moscow area. It is obvious that the technique can also work against this country. H-bombs detonated over the Pacific off the west coast of South America can send streams of high energy particles racing around the lines of the earth's magnetic force field to a "conjugate point" opposite the explosion, producing there auroral storms and a dense artificial ionosphere, opaque to the vital radio and radar links required for control of anti-missiles, radio-guided ICBM's, and long distance radio communications. Theoretically, such an advance "countermeasure" could blind and paralyze military forces for many minutes while missiles fell uncontested on their targets.

• From a scientific standpoint, the Argus tests yielded considerable new data on the structure of the earth's external magnetic field and the puzzle of why there are two separate Van Allen belts trapped in the field instead of just one large belt. The cloud of Argus particles formed a sheet surrounding the earth which persisted for many weeks. By a fortunate chance, the sheet was placed between the two natural radiation belts, so its effects could easily be distinguished. The stability of the artificial shell of particles indicated that the inner radiation belt may be formed by neutron decay (a product of high energy cosmic rays), and not by electrons from the sun.

• The Argus experiments confirmed advance speculation that an artificial radiation belt could be used as a weapon against a manned satellite. They demonstrated that the location and lifetime of the particles in space can be determined by the proper selection of the injection point. This means that a deadly belt of radiation can be focused at will upon a manned space satellite, with all the advantages lying with the aggressor because of the extremely difficult task of shielding a space vehicle within allowable weight limitations. The tests also showed, however, that the earth's magnetic field can become a "tattle-tale" in the matter of detecting clandestine high altitude nuclear tests. Trapped within the field, the particles would be readily detectable to a satellite radiation monitor.

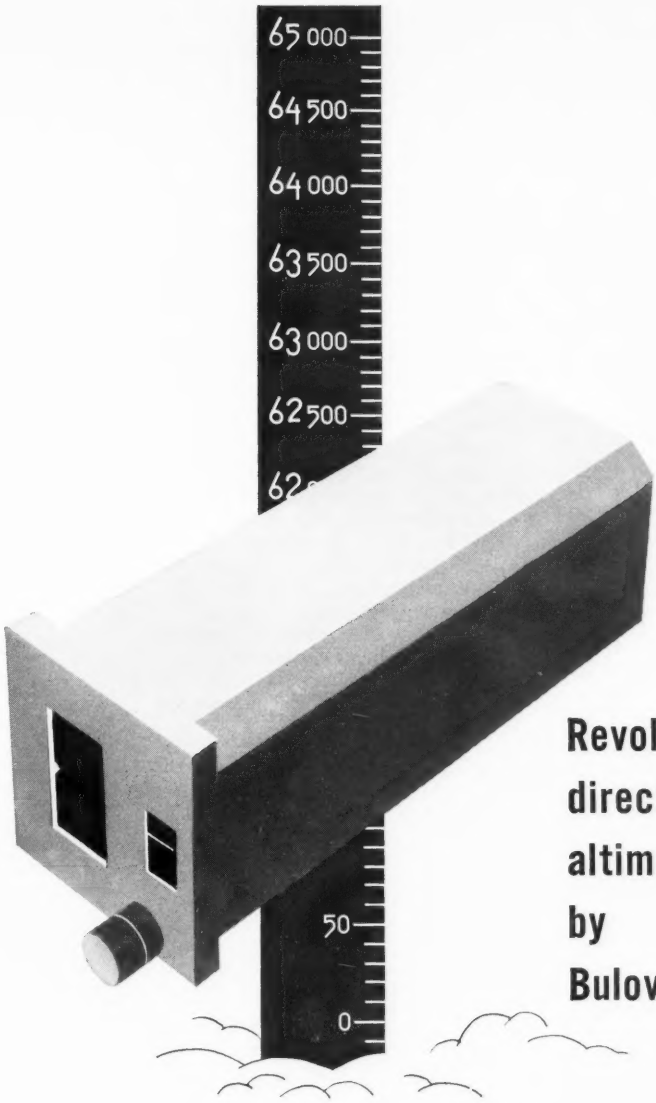
NASA

• The estimated 1960 NASA research and development budget, as presented to the Senate space committee, calls for slightly more than $333 million, or almost as much as the total funding for the agency during its first year of operation.

• Early in March, the Senate approved additional appropriations totaling $48.354 million to support 1959 NASA programs. This money, to be spent by June 30, includes $20.75 million for Project Mercury, $24.25 million for construction of new facilities, many at Wallops Island, and $3.354 million for additional salaries and related expenses.

• In outlining the future for the Senate space committee, NASA scientists told of plans to place radio stations and telescopes in orbit and on the moon, to send man to the moon within a decade, to sample space periodically in different directions and at various times, to launch geodetic satellites and satellites to check the general theory of relativity, and to send probes to the near planets, Mars and Venus. The Solons were so taken by this presentation that they voted to convene the following day to hear more, despite the normal Congressional holiday occasioned by the opening of baseball season.

• The NASA program directed by Homer Newell for planning follow-through research from the results of future satellite and space-probe experiments now has two fully formed working groups—one on orbiting astronomical observatories, headed by Nancy Roman of the NASA Office of Space Sciences, and one on satellite ionospheric beacons, headed by J. C. Seddon of



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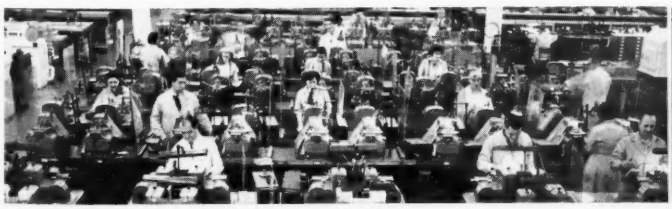

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the NASA Space Projects Center. Dr. Roman's group will explore ultraviolet and IR sun, star, and nebulae spectra, and eventually will be working with telescopes on stabilized platforms in roughly 500-mile orbits. Seddon's group, studying distribution and concentration of electrons and other charged particles in the ionosphere, will work on multifrequency radio beacons for satellites in 200- to 500-mile orbits.

• NASA has granted NSF's National Research Council $350,000 to make appointment, in the form of research positions at the post-doctoral level, and some senior research positions, for theoretical studies of the physics of planets and satellites, astrophysics, plasma physics and cosmic rays, and experimental studies of fields and particles, planetary atmospheres, astronomy, solar physics, and meteorology. Robert Jastrow, head of NASA's Theoretical Div., will direct the theoretical studies; John Townsend Jr., head of NASA's Space Sciences Div., the experimental studies.

• ARPA director Roy Johnson, in testimony before the House space committee, said his agency considers the space above an altitude of 600 miles chiefly the business of NASA. This was taken as removing a potential source of ARPA-NASA rivalry.

MISSILES

• With the release of the Congressional defense appropriation hearings, some of the fog lifts from the confused and bitterly contested question of whether the U.S. is allowing Russia to gain a decisive lead in the ballistic missile field. According to current intelligence estimates, the Russians will achieve initial operational capability with the ICBM this year. They are expected to have 100 next year, 500 in 1961, and 1000 or more in 1962 and later years, provided they undertake an all-out effort. The U.S. now plans only 20 squadrons of Atlas and Titan and two squadrons of Minuteman, for a total of 300 missiles during this same period. Thus, Administration critics argue, the Pentagon is supinely passing over ICBM superiority to the Russians.

For its part, the Administration has pointed out that the ICBM is but one of a considerable number of thermonuclear delivery systems the U.S. has on hand or under development. It notes that a total of 12 Polaris-firing submarines are under construction or advance procurement, that SAC is building up to 14 wings of missile-firing B-52's, that the U.S. forward base system is still largely out of reach of Russian 700- to 1100-mile missiles, that the B-58 and first Snark squadrons are close to operational readiness, and that work is going forward on the Mach 3 B-70 manned bomber.

• With respect to the weight of numbers in the ICBM race, Administration witnesses argued persuasively that a relatively modest number of all-inertial ICBM's in hardened sites is equivalent to many times this number in soft sites. As a consequence, the U.S. plans to install all of its 11 squadrons of Titans (10 each) and its two Minuteman squadrons (50 each) in underground silos capable of withstanding 100-psi blast pressure. Partial hardening (25 psi) will be provided for five of the nine planned Atlas squadrons. The hardened sites mean that an enemy would have to multiply his striking force by five or ten times to achieve the same destruction he might hope to wreak on weapons in unprotected sites.

• Bearing importantly on the great missile debate is the puzzling question of why the Russians abandoned long range ICBM testing for approximately a year before resuming their shots. This intelligence contribution is presumably derived from radar observations of Soviet missile ranges. According to this data, the Russians fired a total of six missiles over "intercontinental" distances between May 1957 and April 1958. Thereafter, no activity was observed until this spring. Because of the very large number of engineering tests which must be conducted to evolve a reliable ICBM system, Pentagon planners believe the Russians are by no means as far ahead of the U.S. as early forecasts suggested.

• One possible reason for the inactivity may have been a decision to modify the Soviet ICBM to a smaller, handier configuration. It's believed that the early models of the Soviet ICBM are extremely large, since they were under development before the thermonuclear bomb was developed and consequently had to be designed for huge fission warheads. There may be partial support for this view, for the Russians continued with their space program even though they performed no ICBM testing. It is believed the Russians encountered two, and possibly three, failures in lunar attempts and several satellite failures during the period of inactivity. The large, unwieldy "first generation" boosters could have been used for this purpose while the ICBM was undergoing modification.

• Opinions on numbers aside, U.S. long range missiles did well in recent tests. The first Snark off Northrop's production-line run was launched from Cape Canaveral toward Ascension Island in a 5000-mile simulated attack culminating in separation of a mock nuclear warhead. A Titan weighing some 110 tons lifted off from Cape Canaveral for the third straight successful developmental firing with just first-stage propulsion. This test vehicle carried the complete Bell Labs radio-inertial guidance package in nonoperating condition for a compatability test. Thor-Able II test vehicles launched from Cape Canaveral toward Ascension Island tested a new reinforced-ceramic nose cone and demonstrated for the first time the complete radio-inertial guidance system under development for Titan by Bell Labs and Remington Rand Univac. The accuracy of this guidance system, and its ability to extrapolate a trajectory, contributed materially to the rapid location of the nose cone some 5000 miles from Canaveral—the first recovery of a nose cone in seven attempts. And, last but not least, two early versions of Bold Orion, the aircraft-launched 1000-mile missile, were tested at Cape Canaveral.

• The European firms hoping to produce the Army's Hawk missile overseas may not get the chance. In view of a Joint Chiefs of Staff Committee rejection of a proposal for an all-altitude defense system based on Nike-Hercules and Hawk, it appears the Army will not deploy Hawk outside this country.

R&D

• Aerojet-General will conduct a feasibility study of a solid propellant rocket motor in the million pound thrust class, with the eventual aim of developing a solid motor that would produce over a million pounds of thrust for two or three minutes.

• The cluster of eight Rocketdyne engines, giving roughly 1.5 million lb thrust as the first stage for the Saturn vehicle, will be ground-tested late this year, with the first flight test scheduled for the fall of 1960.

• Brooklyn Polytechnic's recent three-day symposium on millimeter and submillimeter waves, which offer advantages in broadband and guided long range communication systems, in microwave spectroscopy, and possibly in analysis of the fusion process, gave consensus that practical hardware for generating and guiding such waves appears two to three years away.

• There being more in this world than dreamed of in anyone's philosophy, it is not surprising to hear that members of the Lockheed Missile and Space Div. have applied a missile data processing technique to the diagnosis of arteriosclerosis in its early stages, when it can be effectively treated. Lockheed is working with the Heart Research Foundation and the Univ. of Southern California medical school in the search for an arteriosclerosis cure.

• National Bureau of Standard scientists have developed a method of converting oxygen into ozone by microwave discharge into a U-tube immersed in liquid nitrogen. The process, which can give 100 per cent conversion, may prove economical commercially.

• NSF has made thirteen 1959 grants totaling $1.13 million for laboratory research, field experiments, theoretical studies, and conferences on weather modification.

• Under development at Los Alamos for three years, in conjunction with the Univ. of Michigan, the prototype of a "plasma" thermocouple, employing a uranium–cesium gas junction, recently made the first successful conversion of reactor heat directly to electrical power, running an ordinary light bulb for some 12 hr before it was withdrawn from the reactor for engineering analysis. George M. Grover, head of the project, said that the next phase would be to build a thermocouple capable of producing 5 kw of power. Besides potential commercial application for power generation, such a thermocouple holds promise of becoming an important means of generating power for nuclear-propelled space vehicles and space stations with small reactors.

MATERIALS

• From the four-day meeting of the American Physical Society at MIT comes report of important research advances in solid-state physics. A semiconductor tailored for thermoelectric conversion, indium arsenide phosphide, under study by Westinghouse Research Labs, operates in the temperature range 850 to 150 F and gives 10 per cent efficiency in present devices, and promises much higher efficiencies. Bell Labs research in the past half year has shown superconductivity and ferromagnetism positively related, and points to the synthesis of superconducting alloys for temperatures up to −426 F, new magnetic materials, and superconducting metals made to behave like strong magnets; these advances suggest applications for extremely fast computers operating at low temperature. Harvard Univ., by an extension of maser techniques, has begun development of an infrared quantum detector for very far infrared or submillimeter waves. Research reported on the mean free path of electrons in single bismuth crystals and the form of nickle, cobalt, and iron atoms is expected to amplify present understanding of electrical conductivity and magnetism.

• Tungsten, which melts at 6152 F, can now be spun, deep-drawn, and extruded without appreciable loss of ductility by new techniques developed by Fansteel. In an immediate application of this advance, Fansteel has spun a tungsten nozzle for Kiwi-A, the AEC-Rocketdyne (Rover) test reactor.

• New ingot-melting techniques developed by Johnson & Funk Metallurgical promise to make more practical the welding of titanium and the reprocessing of titanium scrap.

• Wyman-Gordon has made the first large closed-die forging of beryllium.

• The lightweight thrust chamber of U-shaped metal channels and brazed wrapping of thin metal ribbon developed at NASA's Lewis Research Center for high performance liquid rockets will be fabricated by Solar Aircraft.

INDUSTRY

• Requests for new funds and direct obligations for DOD research, development, test and evaluation programs are expected to reach more than $11 billion in 1960, and the lion's share goes to the missile industry—an estimated $2.5 billion slated for new and current work and $2.7 billion for missiles going into service use or inventory.

• The Air Force, which recently reopened bidding on the all-inertial guidance system for Titan, as a consequence of new developments by the group under C. S. Draper at MIT, awarded a contract for Titan inertial guidance to the AC Spark Plug Div. of General Motors. American Bosch Arma, previous contractor, will now supply the inertial guidance for only Atlas.

• Linde Co., which easily won bidding for a five-year contract to supply NASA liquid hydrogen on the west coast, will expand its Torrance, Calif., facility for this purpose. At the moment, liquid hydrogen figures as fuel for the second-stage engine of Centaur (Atlas booster, 5-ton payload in low orbit), an Air Force project under contract to Convair which will transfer to NASA July 1, and for use in Project Rover. Linde will ship liquid hydrogen by tank truck to Nevada for the Rover development.

• The Celanese Corp. plans to enter the field of high energy solid propellants, based on its experience with polymers and synthetic organic compounds.

• United Aircraft is also reportedly set to enter the solid propellant field, with from $40 million to $100 million slated for new facilities. Stanford Research Institute has been doing rocket propellant research under contract for United Research Corp., a UA subsidiary.

EDUCATION

• Following a trend among research institutions, the Univ. of Michigan changed the name of its aeronautical engineering department to the Department of Aeronautical and Astronautical Engineering to reflect its steadily increasing emphasis on space flight, e.g., a series of courses specifically related to space technology and a two-year graduate program in astronautics.

• The Univ. of Connecticut will offer its second annual 10-day Institute on Missile and Rocket Technology beginning July 26, with concentrated seminar-like courses in solid and liquid propellant technology, astrologistics, guidance, satellite mechanics and space navigation, propulsion principles, etc., lead by national authorities in these studies.

• A gift in the form of 30,000 shares of Texas Instruments stock from Mr. and Mrs. Cecil H. Green of Dallas, Tex., will be used by MIT

to create a Center for Earth Sciences with laboratories for interrelated work in geophysics, meteorology, and oceanography. Green, an MIT alumnus, is a vice-president of Texas Instruments.

• The Science Manpower Project of Columbia Univ. Teachers College has developed, and issued in book form, a curriculum for high school physics that can be used to modernize existing courses.

• The Senate Committee on Government Operations has issued a summary of its study of the vital relation of the Government to the nation's science and technology and the advisability of a Department of Science and Technology. Hearings on the Science and Technology Act of 1959 began last month.

GREAT BRITAIN

• With the launching of a second Black Knight rocket recently at the Woomera range in Australia, Great Britain moved closer to entering the ballistic missile field. The first Black Knight, launched last Sept. 7, reached an altitude of 300 miles; the second one reached 350 miles. The 35-ft-long, 3-ft-diam Black Knight employs a four-nozzle liquid propellant engine which, burning HPT and kerosene, gives a sea level thrust of 16,400 lb. It carries instrumentation for telemetering ascent and re-entry conditions.

• These firings, which in part served to introduce Woomera crews to the handling and tracking of big ballistic rockets, prefigure the first flight testing of Britain's liquid propellant intermediate range ballistic missile, Blue Streak, some time in the fall.

• Just before this launching, Paul Leyton, who headed the Saunders-Roe development team on Black Knight, left the project to become technical director of the Black and Decker power tools company. Statements attributed to him suggest he left because of a reluctance of the British government to commit the country to a program of space research.

• The newly formed National Committee on Space Research, set up to coordinate British upper atmosphere research and to cooperate in international space projects, held its first meeting in London recently. H. S. W. Massey chairs the committee.

EUROPE

• France continues to expand its missile testing facilities center near Colomb-Bechar in the Sahara, reportedly in preparation for testing a solid propellant intermediate range ballistic missile and an associated satellite-launching rocket of its own design. If the French succeed in developing an atomic bomb, it will probably be tested in this area also.

• Several French-built Veronique and Monica rockets have been fired since the beginning of the year from Colomb-Bechar for upper atmosphere research.

• West Germany will not be able to show much activity in the missile field in 1959. The only Bonn financed missile industry, Bülkow, has thus far been charged with research and development activities only, and not permitted production of any missile. German firms continue to instruct themselves, however, in missile technology, and some, such as Telefunken, could bid for European production of the U.S. Army's Hawk ground-to-air missile.

• French and Italian firms bidding strongly as possible Hawk manufacturers are Thomson-Houston and Finmeccanica.

• It has been heard that West Germany plans a missile test range on its northern coast and islands.

• Italy received 100 Falcon solid propellant rocket motors from the U.S. for testing the Italian C-7 air-to-air missile, its own motors not yet being available.

• General E. Savi of the Italian Air Force has been appointed chief of CORMI, Italy's main government agency and interservice coordination group for rocket development. The Italian Air Force feels that its range on Sardinia would adapt nicely for the testing of Hawk missiles manufactured in Europe.

• Sweden has built a missile test range with British equipment on the Baltic.

INDIA

• India has shown interest in acquiring a low-cost anti-tank missile similar to the ones being produced by several European countries.

RUSSIA

• Soviet scientists are still reaping data from Sputnik III, as its radio batteries recharge through solar cells. The continued transmittals from Sputnik III may account for the signals picked up by Belgian and German amateur radio operators, and reported as a possible new Soviet satellite.

• References in the Russian literature point to Soviet programs for putting man in space, establishing a TV repeater station satellite, and testing the general theory of relativity by a satellite with an atomic clock.

• Academician L. I. Sedov, in a Pravda interview, congratulated U.S. scientists and engineers on the success of Pioneer IV, commenting that, "side by side with the launching of large rockets similar to the Soviet cosmic rocket. . .small Pioneer-type rockets for scientific research operations are very useful."

• At the Fifth Assembly of CSAGI (Conference of East European-Asian Countries for Continuous IGY Investigations) held in Moscow, scientists from Communist block nations, including Red China and Yugoslavia, accepted a resolution for continuing cooperative IGY activities during 1959, and discussed mutual technical aid and problems of data reduction and dissemination.

JAPAN

• Local elections in Honmura Village cleared the way for the Japanese Defense Agency to build the country's first guided missile testing site on Niijima island in the Izu group.

• According to Yuichiro Aono, member of Japan's Cosmos and Space Research Committee and deputy director of the government's Radio Wave Research Institute, Japanese rocket experts are now designing a three stage vehicle capable of reaching an altitude of 80 to 100 km. Instruments flung out from this rocket on the end of wires will make a series of measurements in the ionosphere.

• Some Japanese ceramics manufacturers would like to cooperate with U.S. companies in the development of ballistic missile nose cones, but find effective opposition to this work from certain government groups. Also, many Japanese industrial concerns and members of educational institutions are now calling for a bigger national missile and rocketry program.

• The Mitsui company of Tokyo has become exclusive agent in Japan for select Aerojet-General products, including Aerojet Jato units and the Aerobee series of sounding rockets.

READY

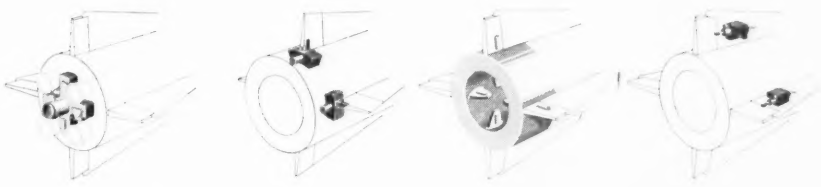
ONLY LEAR ELECTRIC SERVOS ARE MAINTENANCE-FREE AND *ALWAYS* ON THE ALERT

To help keep the peace, today's missiles must be instantly ready to fire as the Sheriff's six shooter of old. Delay or failure is fatal. Lear Electric Servos—even after "standing by" for three to five years—give this sure fire readiness to the nation's missile arsenal.

Lear Electric Servos provide more fire power per dollar by eliminating constant, high-cost maintenance required by other types of missile actuators. Lear's servo actuators save manpower, equipment and money. They are field tested and stand ready to "take over" instantly in missile jet vane, air vane or elevon actuation.

This proven action performance plus economy, both in-flight and "on the ready," has won enthusiastic Army and Air Force acceptance for surface-to-surface and air-to-ground missile applications, and Lear electric servos can be designed to be an integral part of any known missile.

Select your servo from this field tested line.



LEAR

G-4

GRAND RAPIDS DIVISION

110 IONIA AVENUE N.W., GRAND RAPIDS 2, MICHIGAN

Senior staff openings in basic research

THE BOEING SCIENTIFIC RESEARCH LABORATORIES are engaged in a program of fundamental research designed to make contributions to the progress of the physical sciences. High-level staff positions are open now in the fields of

Gas Dynamics
Plasma Physics
Mathematics
Solid State Physics
Electronics
Physical Chemistry
Geoastrophysics

Boeing grants scientists the latitude and independence needed to achieve and maintain leadership in their special fields. Scientists interested in carrying on their work in this kind of stimulating research environment are invited to communicate with Mr. G. L. Hollingsworth, Associate Director, Boeing Scientific Research Laboratories.

P. O. Box 3822 - ATA
Boeing Airplane Company
Seattle 24, Washington

BOEING

The mail bag

Metrological Enthusiast

Dear Sir:

My admiration for the industry and vigilance which enables you to print so much information about Russian extraterrestrial vehicles is great.

But, to the metrologically educated, your results appear to be inept, because in striving to avoid a simple, standardised, and scientific metric system, they get lost in a maze of mutilated measures. The figures given by you (February 1959, page 17) on Lunik I are vitiated by obviously inadequate conversions.

Why do you not adopt for all extraterrestrial experiments the only system of weights and measures suited to it, namely the metric system?

OLIVER STEWART
Editor, Aeronautics Magazine
London, England

Dissenting View on Antennas

In the article "Communicating with the Hypersonic Vehicle" by Homic and Phillips in the March 1959 issue, a graph is presented (page 37) giving their calculations of shock layer attenuation over the frequency range "20 kc per sec to 20,000 mc per sec." Although any present approach to this problem involves approximation of one form or another, one point which should not be left to go unchallenged is their conclusion on the basis of that graph that the lower the frequency, the better the situation.

While Homic and Phillips proceed to argue (page 94) against low frequencies on the basis of "excessive reflections," and conclude extremely high microwave frequencies are needed, it would undoubtedly occur to many antenna engineers (noting the difficulties in components at such high frequencies, and the hundreds of db attenuation at the more commonly used frequencies) to consider the possibilities of using the very low frequencies with servo antenna impedance matching. The low radiation efficiences of antennas at low frequencies may still look attractive compared to the hundreds of db attenuation or the component difficulties suffered otherwise.

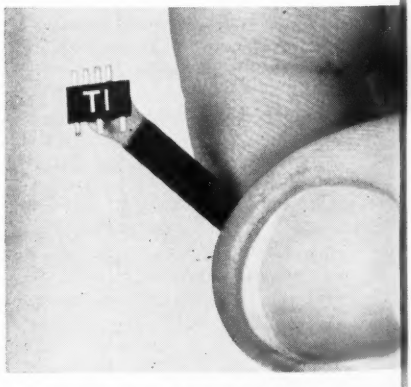
However, some time back, in connection with similar work here at Hycon Eastern, we carried through some extensive electromagnetic theory calculations involving a radiating system surrounded by a shock wave layer, and found a very significant and easily explained additional effect occurring at lower frequencies. Namely, below a certain frequency, the attenuation would again increase with decreasing frequency, so that, from the attenuation viewpoint, there is in fact an optimum low frequency (whose value depends on the parameters of the problem), rather than an optimization at the lowest possible frequency.

The reason for this, which would not appear in the ray tracing type of calculation which Homic and Phillips imply, is that at low frequencies, the ionized region is electrically very close to the antenna. The near-zone fields which are ordinarily reactive and nonpower carrying fields will then produce currents in the ionized region which becomes large with respect to the currents associated with the radiation field components and cause quite a large amount of added loss.

Obviously, also, the lower the frequency, the more severe this effect, and the higher these near-zone currents and ohmic losses will be relative to the radiated power. This, in fact, also leads one to the conclusion that at least part

Semiconductor Advances

Texas Instruments recently announced two important advances in semiconductor technology. First, the laboratory forming of diode and transistor elements together with passive elements of resistance and capacitance as integral solid circuits about the size of a matchhead. With component densities up to 34 million/cu ft achievable, according to the company, this technique approaches the ultimate in miniaturizing complex electronic circuitry and components. Second, the development and manufacture of a gallium arsenide diode capable of operating between −82 and 628 F—almost double the temperature range of semiconductor devices now commercially available. This diode, dissipating 800 mw at 77 F, gives double the power available from a standard subminiature glass diode case.



Shown against matchhead, this silicon solid circuit multivibrator developed by Texas Instruments contains the equivalent of 12 electronic components: two diffused-base transistors, two capacitors, and eight resistors. These complex and compact solid-state systems are expected to find wide use in missiles and space vehicles.

of the problem of using lower frequencies lies in selecting an antenna which is optimum in the sense of minimum near-zone field losses, as well as radiation. That such a distinction can be made has also been borne out in calculations.

I might also add that our results indicated that at any of the frequencies at which severe attenuation is likely to occur, the resulting radiation patterns are likely to be those of a simple fat dipole.

Finally, the article might well have mentioned the likelihood, at the altitudes involved, of a.c. breakdown of the air in the region of the antenna, as a possible source of even further ionization, and hence an additional problem in antenna system design.

SEYMOUR STEIN
Hycon Eastern, Inc.
Cambridge, Mass.

Lunik Rocket Coming?

Dear Sirs:

I am surprised you did not ask for a complete Lunik rocket in your "Open Letter to the U.S.S.R." (February 1959, page 16).

You would have received it postpaid.

F. P. BALTAKIS
4545 Osprey St.
San Diego, Calif.

Subject: Covers

Dear Sirs:

Your program of covers for ASTRONAUTICS has been a source of considerable pleasure to me. I am particularly taken by the February 1959 cover.

I am wondering if the original painting might be available for purchase or borrowing? I am interested in acquiring it.

Thank you for your consideration of my interest.

BEARDSLEY GRAHAM
XA Planning Manager
Lockheed Missiles and Space Div.
Sunnyvale, Calif.

Mr. Graham has been placed in touch with the artist who painted the February cover—Editor.

Dear Sir:

I would like to add my name to the list of those interested in reproductions of some of your excellent covers. I am more than willing to purchase them at cost. Covers from March, June and July 1958, are especially desirable.

I find the articles in your magazines ASTRONAUTICS and ARS JOURNAL most helpful in my work. Keep up the good work.

GEORGE T. KELTON
White Sands Missile Range, N.M.

Initial Error

Gentlemen:

On page 29 of the story entitled "Instant Rocketry" in January, reference is made to an "R. E. Cox" of Cooper Development Corp. This is in error, since the gentlemen concerned was not R. E. Cox but R. B. Cox.

Cooper does employ an R. E. Cox, but this is not the individual who was on the solar eclipse expedition.

MARY PLANCICH
Cooper Development Corp.
Monrovia, Calif.

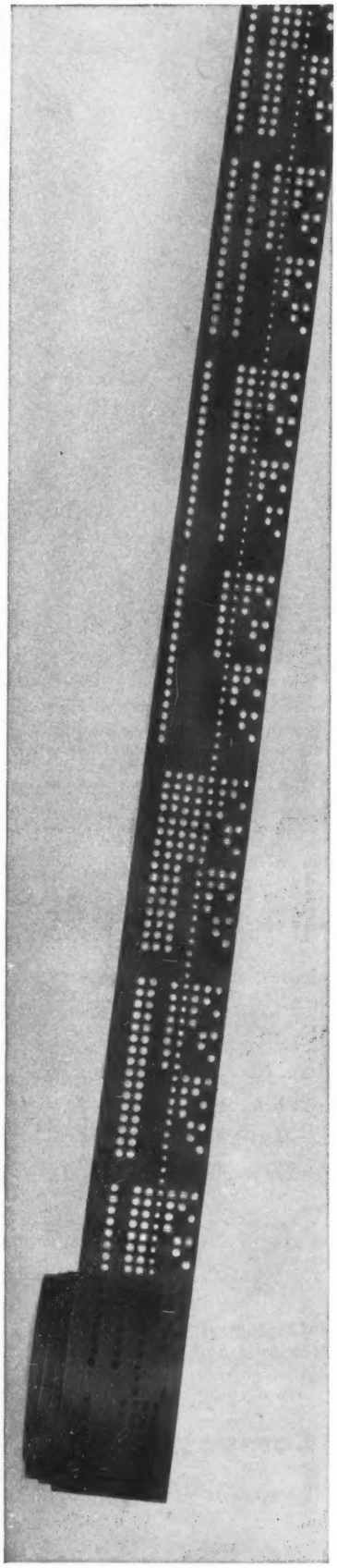
Ideas for missile engineers

Hackney components—deep drawn shapes, shells and parts—offer designers many advantages, including:

- **great strength with minimum weight**
- **elimination of heavy castings, forgings, etc.**
- **maintenance of exact diameters, wall thicknesses**
- **simplification of assemblies to speed installations**
- **naturally smooth surfaces which are easy to paint, clean, maintain**
- **making parts in ten different metals**
- **maximum latitude in designing; for example, wall thicknesses .050" to .700"...working pressures to 6000 psi...as well as ample design latitude in capacities, diameters and depths**

For engineering facts, data on components already produced by Hackney engineers for missile and rocket projects, write to the address below.

Pressed Steel Tank Company
Manufacturer of Hackney Products Since 1902
1476 South 66th Street, Milwaukee 14, Wisconsin
Branch offices in principal cities
CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS



Now, completely a

Honeywell's Compact Random Access Programmer, using solid state switching techniques, makes checkout and countdown fast, accurate, reliable.

When a production missile goes to the field it has to be ready—all the time.

The crew must know, first, that each system, subsystem and component crammed into the missile works perfectly; second, that after launching each will function in a precisely predetermined sequence.

This demands highly accurate surveillance and constant checks, achieved with an absolute minimum of equipment and personnel.

Programming and checkout equipment now being used is for the most part expensive and inflexible, with a low reliability factor. Logistics of coordination are puzzling and uncertain. Since thousands of conventional, mechanical relay switches are necessary, programmers are large and cumbersome; and any change in the logic of the missile system means that checkout equipment must be redesigned to conform.

Many of these problems are solved by Honeywell's Random Access Programmer, a distinct advance in the state of the art. It applies solid state techniques whereby tiny magnetic switches replace mechanical switches, making possible remarkable reductions in bulk and greatly increased signal speed, longevity and reliability.

MISSILE TEST ON TAPE

Pre-punched tape fed into compact random access programmer can monitor a missile continously through all phases of checkout and countdown procedures.

Random Access Programmer Check Out Equipment

automatic missile checkout

Solid state switching, random access and punched tape make the Honeywell programmer a fully automatic device that can be designed to monitor any missile throughout all phases of checkout and countdown procedures. The console contains comparator equipment that measures temperature, pressure, frequency, voltage, current, speed, time, weight, resolution and drift.

What's more, the Honeywell programmer is the only system which, when a malfunction occurs, sends a coded message to the operator pinpointing its location.

Advantages

Size. A conventional, mechanical switch with 1,024 switch points occupies 48 cubic feet. The same number of switch points in Honeywell's solid-state switch makes a package only *one-quarter* of one cubic foot.

Speed. Response steps up from milliseconds to microseconds. The new Honeywell Random Access Programmer is capable of a command rate of from 12 to 300 commands per second.

Long life. No moving parts, nothing to break, nothing to wear out. Mechanical and nuisance failures are virtually eliminated.

Flexibility. Because punched tape is the language of the system, even major modifications in the missile require merely a change of tape. No design changes in the checkout equipment are needed.

Malfunction Indication. During checkout and countdown the Honeywell device monitors the missile automatically through signals fed into it in a predetermined sequence. If a malfunction occurs, the device searches, finds and localizes it, then notifies the operator remotely by means of a coded signal. Meanwhile, the missile has been made safe. Repairs may be made quickly.

The new Compact Random-Access Programmer is essentially a data handling system. As such, it's a logical result of Honeywell's 15 years of experience in the accumulation, processing and presentation of data in practically every type of industry. The new device simply represents a wealth of competence turned to military application by the Missile Equipment Division of Honeywell's Military Products Group. It's logical, too, that the new equipment should have many points of technological superiority. For Honeywell development and production capability is devoted to producing a majority of the same missile systems and components that the programmer must check. Corporate-wide support is readily available from other divisions as needed—Datamatic, Seattle Development Laboratories, Aeronautical, Ordnance and Boston divisions, and others.

Since the corporation's business is *measurement* and *control*, the results of much research, development and production across a wide range of closely-related effort is incorporated in the work of Honeywell's Missile Equipment Division.

For a demonstration of solid state checkout—programming system, write Honeywell, Missile Equipment Division, Pottstown, Pa.

Honeywell

Military Products Group

For the record

The month's news in review

March 1—AF reports it is receiving signals from Discoverer which indicate satellite has achieved orbit. Scientists cite rivalry among space programs as a factor in early failure to track the satellite.

—An underwater missile detection system in the Wake Island area scheduled for testing this week will mark exactly when and where a test missile launched from the Pacific Coast hits the water. Similar systems, to be completed by July 1, are planned for Kwajelein and Midway.

March 2—DOD Secy. Neil H. McElroy tells House committee administration's rejection last fall of Army's request to start production of Nike Zeus missiles was based on "best scientific opinion" missile was not far along in development, although admitting scientific opinion was divided.

March 3—Army successfully launches Pioneer IV lunar probe, with 13.4-lb payload expected to pass within 37,000 miles of moon and go into orbit around the sun.

—President asks Congress to okay study of radio spectrum allocation.

—Sen. Stuart Symington is named to head new Senate Space Subcommittee to investigate rivalry and duplication in space programs.

SENIOR RESEARCH ENGINEERS

Challenging and rewarding positions are available in a wide range of assignments on programs, both basic and applied, related to missiles, ships, submarines, space vehicles, nuclear power, pressure vessels, off-shore drilling systems, and weapons effects. These positions offer an outstanding opportunity for work in theoretical and applied mechanics and mathematics. We are expanding our programs and are looking for aggressive individuals with creative know how and imagination. Salaries are open. Candidates should have an M. S. or Ph.D. degree with research experience desirable. Please send resume and salary requirements to:

R. C. Mays, Personnel Director

SOUTHWEST RESEARCH INSTITUTE

8500 Culebra Road

San Antonio 6, Texas

March 4—NASA says Pioneer IV passed the moon today at a speed of about 4500 mph on its way into heliocentric orbit.

—AF announces it has fired nuclear-designed nose cones down into the atmosphere at speeds of more than 17,000 mph from B-57 bombers.

March 5—ARPA says Discoverer satellite is definitely in polar orbit around the earth.

March 6—Pioneer IV sets record for long range communications, transmitting radio signals over a 400,000-mile-range before falling silent.

March 7—New 35,000-ft sled-test track is dedicated at AF Missile Development Center, Alamogordo, N.M.

March 9—AF designates Lincoln, Nebr., as site for ICBM base.

March 10—AF Snark launched from Cape Canaveral makes successful round-trip ocean flight.

—NASA reveals it is developing "poor man's" launching rocket known as Scout for $500,000.

—Senate authorizes $48,354,000 increase for nation's space program.

—X-15, slung under wing of B-52, is carried aloft for first time, with test-pilot Scott Crossfield in cockpit.

March 13—First ultraviolet pictures of the sun are taken in Aerobee-Hi rocket firing from White Sands.

March 14—U.S. offers to launch earth satellites of other nations at meeting of ICSU Committee on Space Research (COSPAR).

March 16—Two-stage AF "mystery missile" is fired from Cape Canaveral.

March 17—ARPA says, "It must be presumed Discoverer I is no longer in orbit."

March 18—AF Atlas, with new recoverable nose cone, fails after 800-mile trip.

March 19—MIT reports that a team of its Lincoln Lab scientists sent to and received signals from Venus last year.

—U.S. reveals Project Argus tests.

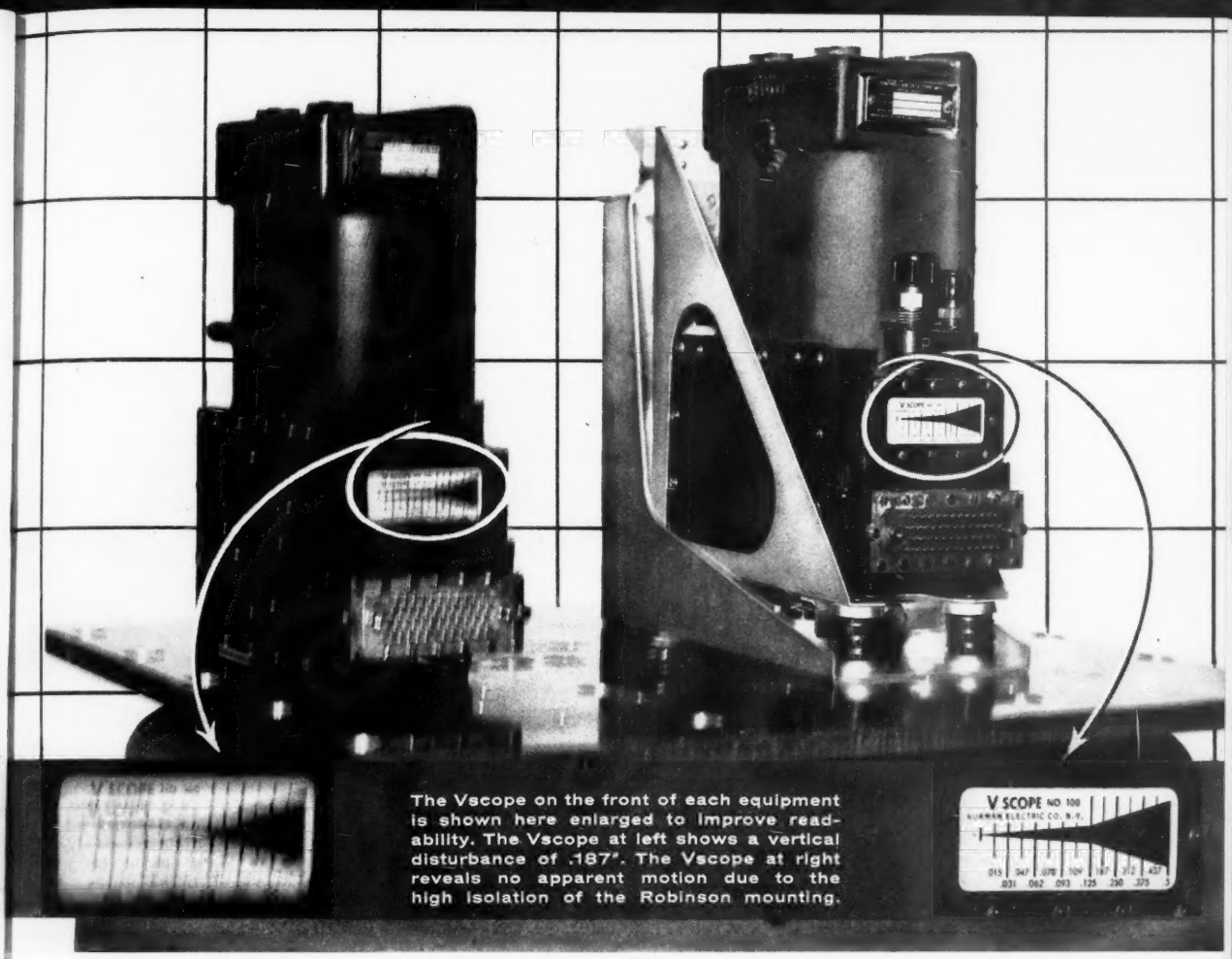
March 21—AF Thor-Able nose cone is lost in Atlantic after successful 5000-mile flight.

March 24—Homer J. Stewart of NASA reveals plan to fire new satellite soon to study radiation at an altitude of 25,000 miles.

March 26—NASA reports models of satellite space capsules have passed preliminary flight tests.

March 29—Secy. McElroy considers high-priority Navy plan to speed production of Polaris missile submarines.

March 31—Navy announces plans for radio relay between Washington and Pearl Harbor by way of the moon.



The Vscope on the front of each equipment is shown here enlarged to improve readability. The Vscope at left shows a vertical disturbance of .187". The Vscope at right reveals no apparent motion due to the high isolation of the Robinson mounting.

12.0 "G" reduced to 0.6 "G"

This Is Environmental Protection!

Look at the above illustration, showing two Bendix air data sensors on an electromagnetic shake table. Notice the left hand unit which is mounted solidly to the oscillating head of the shaker. The image is blurred because a vibratory input of about .187" double amplitude at 35 c.p.s., equalling an acceleration force of 12 "g's", is being applied directly to it.

Now look at the right hand unit mounted on a Robinson engineered mounting system . . . some difference! The clear image of this equipment shows the typically high isolation efficiency (over 95%) of the Robinson MET-L-FLEX® mounting design.

Other Robinson designs provide similar protection at higher frequencies where the input often reaches 30-40 "g's". The natural frequencies of such mounting systems are held within limits which are not critical to the equipment.

Utilizing this mounting system radically reduces the environment to a level easily tolerated by any reasonably well designed electronic equipment. Such a mounting eliminates the need for costly and time consuming ruggedization. Over-all space and weight are held to a minimum.

Because of the proven performance and reliability record of airborne components *now* protected by Robinson mountings, an increasing number of manufacturers in the electronics industry are incorporating Robinson mountings as an *integral part* of their basic equipment design.

"Performance is the reason . . . Reliability the Result"

ROBINSON *Technical Products Inc.*

TETERBORO, N. J.

Formerly ROBINSON AVIATION INC. • West Coast Engineering Office: Santa Monica, Calif.

DESIGNERS AND MANUFACTURERS OF VIBRATION CONTROL SYSTEMS

NEW DIMENSIONS IN

reliability

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to find, and not to yield"
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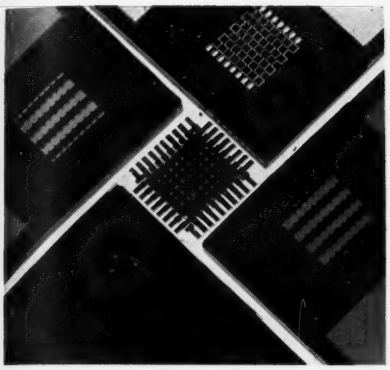


COVER: *Deposited in layers only 1000 Å thick on a microscope slide, this microminiature, superconducting computer memory plane, developed by IBM's Military Products Div., represents a density of 160 bits per sq in. The plane, containing 64 cells in a 3/8 in. square, is composed of 13 thin film evaporations of lead and silicon monoxide. The memory function is provided by storage of persistent current in the superconducting structure. Operated in a liquid helium environment at 4.2 K, a typical plane can provide a one-microsecond memory cycle.*

Astronautics

MAY 1959

Playing with Fire

"St. Cloud, Minn., March 28 (AP)—A 14-year-old boy was taken off the critical list today following surgery to remove a 6-in. metal rod driven into his head by an exploding homemade bomb. . . .The boy was apparently using the rod, 1/4 in. in diam, to tamp matchheads and other explosive material into a pipe . . ."

"New York, N.Y., March 28 (AP)—A teenager blew off his right hand last night while experimenting with rocket fuel mixtures in a Bronx lot. Larry Burman, 16, also suffered burns of the legs and abdomen while mixing four liquid chemicals . . ."

There are those in the ARS who insist that homemade fireworks are indispensable training aids for space education programs. Fireworks have been banned by most communities on their hazard and nuisance record. Their value as training devices needs weighing against these hazard and nuisance factors, along with careful discrimination between mere toy appeal and the subtler menace of inciting pyromania. It is entirely possible to teach first aid without putting morphine hypodermics into the hands of unlicensed amateurs.

Homemade rockets are no longer the research tools they were in the days of Dr. Goddard. It seems inconsistent for ARS members to advocate homemade rockets for children when they see no need for sponsoring serious amateur rocket research by their own Sections because their time is taken up by reports on professional-level research from accredited laboratories.

A more mature approach to Section responsibility in this area is indicated in the community space education program recently inaugurated by the Maryland Section under the able direction of Charles W. Hoffman, chairman of its Education Committee. The Section is giving a series of educational lectures for teachers in the area, and more than 70 have responded gratefully and enthusiastically.

If a continuing interest by teachers, who have the recognized responsibility for educating our youth, is manifested in such programs, it is far more likely to produce future rocket engineers than children playing with fire.

JOHN P. STAPP
PRESIDENT, AMERICAN ROCKET SOCIETY

Microminiaturized payloads open paths for space research

Launched with cheap mass-produced rockets, they will bring active space research programs within the reach of scientists of any laboratory or nation

Howard A. Wilcox

OFFICE OF THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING, WASHINGTON, D.C.

Howard A. Wilcox is the recently appointed deputy to Herbert York, director of research and engineering for the Dept. of Defense. Dr. Wilcox previously served for eight years at the Navy's Michelson Lab in China Lake, Calif., as project engineer for the Sidewinder missile during its early design and development, then as head of the Weapons Development Dept., and most recently as assistant technical director. He received a Ph.D. in physics from the Univ. of Chicago in 1948, and before becoming a government scientist taught physics and did research in high energy nuclear physics at the Univ. of California.

I SUPPOSE man has dreamed of flying since he's been human. Perhaps even the apes feel dim yearnings to imitate the birds around them. But man's first desires to invade outer space were no doubt kindled rather recently, when his conception of the satellite earth and the interplanetary void were first mixed into his primitive views of the cosmos. Some 17 years ago, he first hurled objects beyond earth's atmosphere. Now, man himself is tensed for the leap.

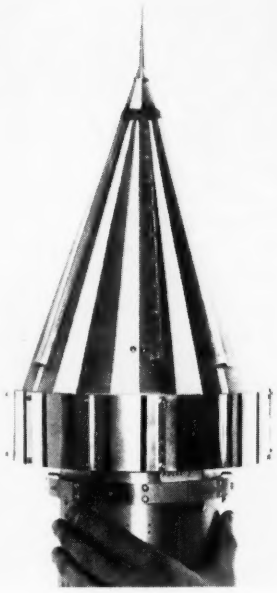
In every great exploration, men have died. But always hope has triumphed over early setbacks. So it will be again. It is perhaps true—and also perhaps comforting—to note that the first man to invade space will run risks not greater than those met by Columbus on his first voyage—or by a frontline soldier during two hours of active combat—or by a big city pedestrian!

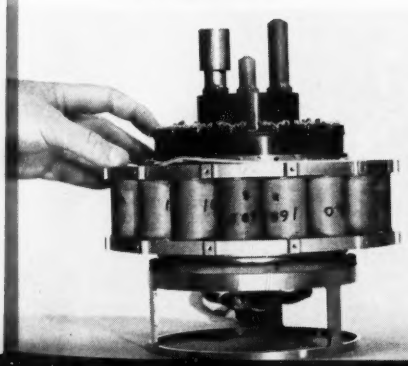
Trail Will Be Blazed by Instruments

And this is so because this first man will be following a trail blazed by instruments. Newell's detectors have explored the ultraviolet and the x-radiations filling the vacuum just beyond the top of the earth's air. Van Allen's counters have discovered seas of particles trapped in the earth's magnetic field. The gadgets of LaGow, Dubin, and Nazarova have sampled the micrometeor populations of local space. The dog "Laika" and the monkey "Old Reliable," while dying, have helped to prove that man can live in outer space and then return safely to earth.

Today, the U.S. and the U.S.S.R. are engaged in a friendly but vigorous race to top each other in tossing tons of metal into orbit. Such a race seems good in many ways. It is certainly moving man quickly into the realm of space travel. Perhaps it is contributing importantly to man's ability to survive.

But there is another side to the business. Space vehicles are large and costly. Other things being equal, one pound cut from the weight of the space payload can mean hundreds—or thousands, or even tens of thousands—of pounds saved in the design of the space vehicle as a whole. Larger vehicles are, in some ways, inherently more difficult to build and to operate (CONTINUED ON PAGE 95)





Midget payloads for giant missions

Microminiaturization of satellite and space probe components permits important experiments to be carried out at a minimum cost

THE GARGANTUAN chemical rockets being developed under the direction of NASA will be able to put tons of instruments into orbit and send hundreds of pounds to the moon and nearby planets. What need then for more than a testimonial to current cleverness in miniaturizing instruments for payloads, when in the near future there is prospect of launching a whole laboratory of fairly conventional instruments, and man besides, into space in one shot.

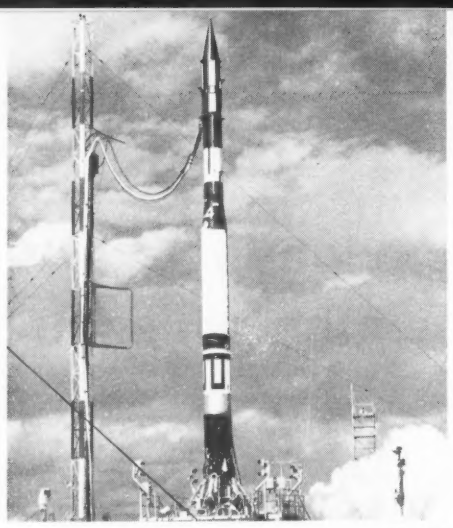
Part of the answer can be given in terms of launching vehicle cost—just the cost of rocket propulsion systems today and for years to come. Homer Stewart, NASA's director of program planning and evaluation, puts the *direct* cost of satellite and space probe systems at a conservative $10,000 per pound of payload for a payload to gross system weight ratio of 1000 to 1—that is, at the very efficient ratio of Vanguard II. The cost of a 3000-lb payload—for instance, like Sputnik III or the coming Mercury capsules—will be high.

On the other hand, rockets specifically designed to carry small payloads for space projects can attain payload to gross weight ratios of about 25 to 1. Dr. Stewart expects such rockets to have a cost per pound of payload as low as $300.

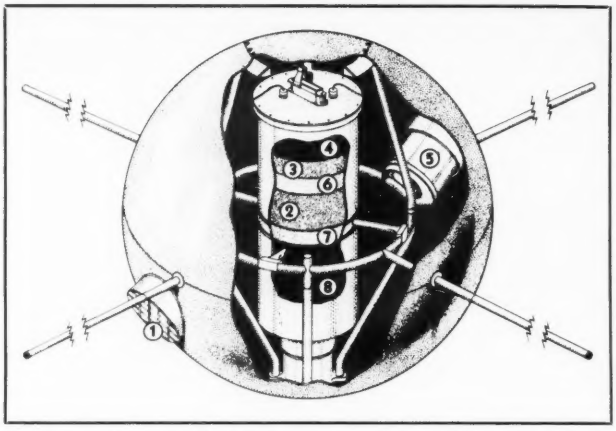
Miniaturized payloads thus appear to have long-range benefits of economy, and present the possibility of widespread and continued space experimentation by institutions and industries with modest budgets.

As suggested in articles in this issue of ASTRONAUTICS, appropriate methodology for space and upper atmosphere research, as well as logical design of instruments to operate in space, offer strong complimentary arguments in favor of diverse miniaturized payloads.

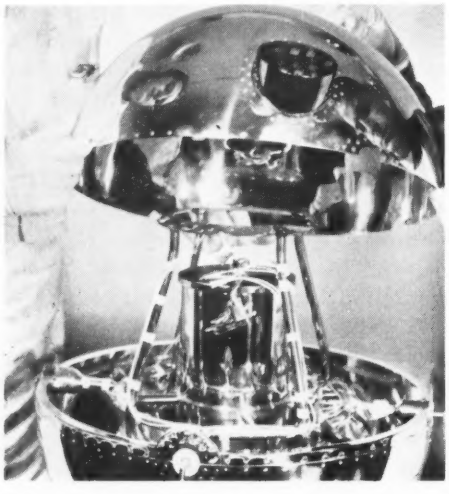
Huge Juno II launching vehicle (top left), 76 ft long and weighing some 120,000 lb, was required to propel 13.4-lb Pioneer IV payload to escape velocity in Army's attempt to hit the moon March 3. Center, size of 13.4-lb Pioneer IV can be judged from this photo. Designed by JPL, its fiberglass outer shell is gold-washed to provide conductivity, while the striped pattern regulates temperature by controlling reflection and absorption of solar heat. Bottom, microminiaturization enabled JPL scientists to cram two major experiments into tiny instrument package. Two larger tubes at top measure radiation, smaller is voltage regulator. On deck below is radio transmitter, surrounded by batteries. Lens of photoelectric scanner is visible at bottom

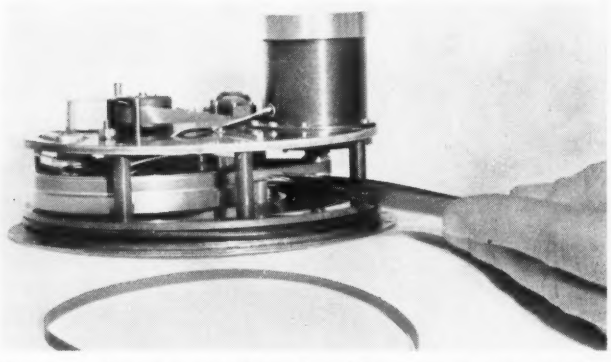


Forward-looking in design, the trim 22,600 Vanguard II put first "weather" satellite into orbit Feb. 17. The 21.5-lb satellite, shown below, contained a nest of microminiaturized instruments for measuring cloud cover.



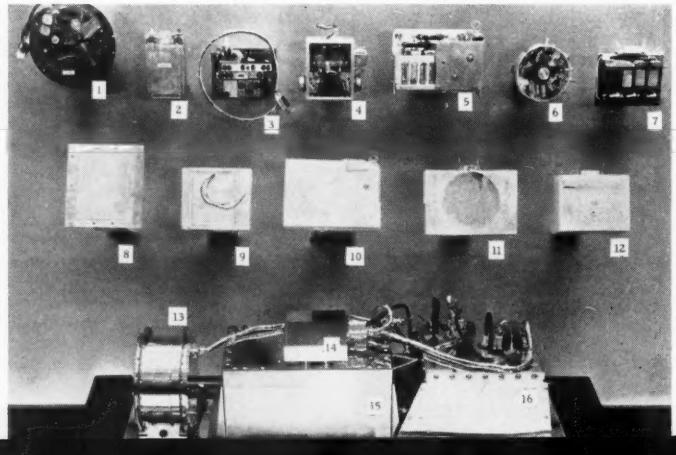
Cutaway of Vanguard II shows components: (1) Photocell light shield, (2) recorder, (3) interrogation radio receiver, (4) meteorological data transmitter, (5) photocell, (6) data processing equipment, (7) tracking transmitter, and (8) mercury cell batteries.

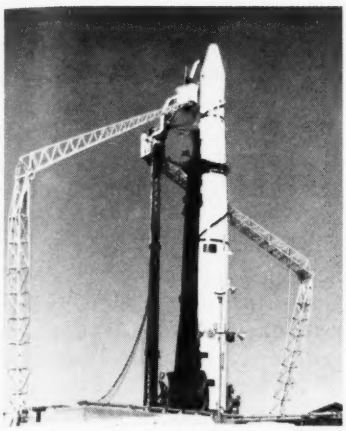


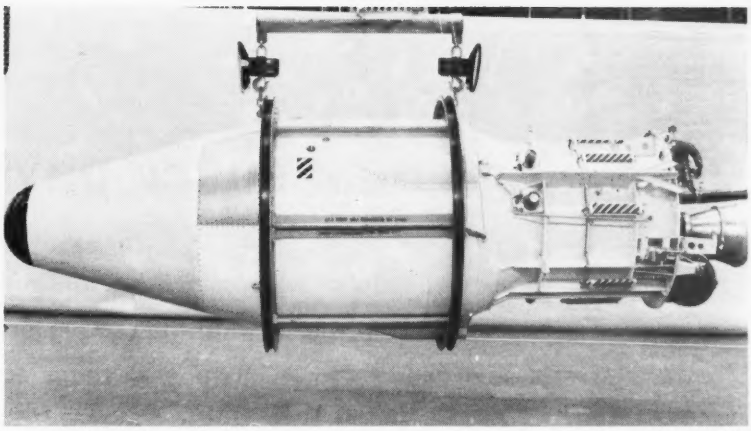


Data recorder of the kind developed by Army Signal Labs for both Vanguard II and Atlas-Score. Vanguard II carried 75-ft-long continuous loop of special 3M magnetic tape.

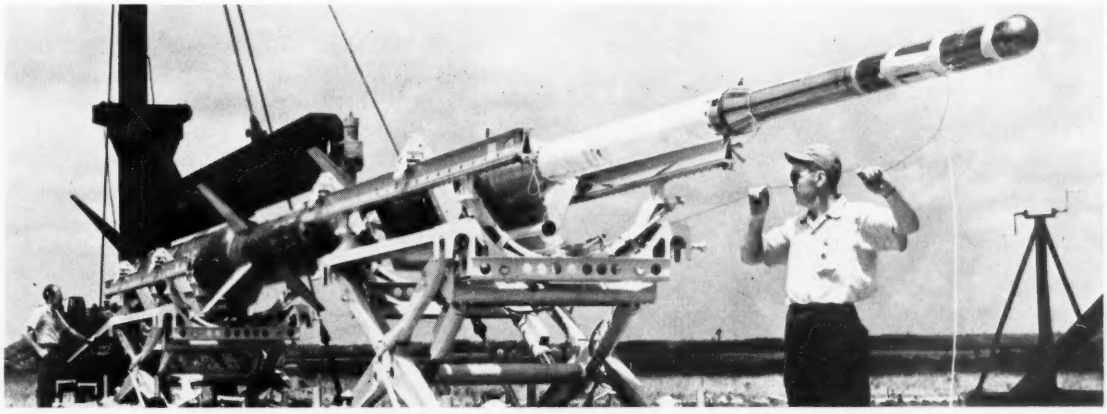
This Atlas (below left), weighing about 121,000 lb, orbited the empty 8700-lb sustain stage with two $35\frac{1}{2}$-lb communication relay packs in Project Score. Below right, the Score relay package based on miniaturized radio equipment. Top row: (1) tape recorder, (2) one of 10 silver-oxide batteries, (3) receiver, (4) DC-DC power converter, (5) 8-watt transmitter, (6) beacon transmitter for full-time tracking, and (7) control unit. Second row, components potted in plastic foam: (8) receiver, (9) converter, (10) transmitter, (11) beacon transmitter, and (12) control unit. Bottom, system as pod mounted on Atlas: (13) aluminum canister for tape recorder and associated electronics, (14) receiver canister, (15) gold-plated canister for batteries and converter, and (16) aluminum canister for transmitter, beacon, and control unit. See page 37 for complete description of the Score system.



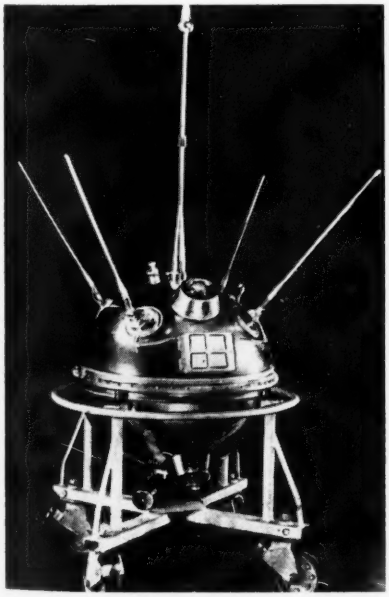




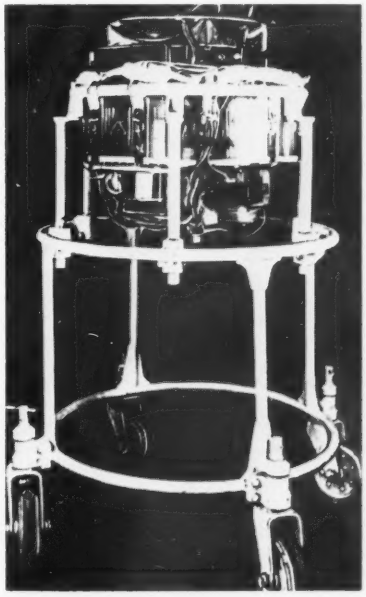
Discoverer I, consisting of a Thor booster and Hustler second stage, with a total weight of more than 100,000 lb, delivered the empty 1300-lb Hustler stage (right), which included an experimental attitude-stabilization system and 40 lb of radio and tracking equipment, into polar orbit Feb. 28. Although the payloads of such systems look large, they are mostly dead weight, and much of their usefulness comes through lightweight, miniaturized equipment, e.g., transmitters and beacons.



Miniaturized instruments will see continued use in economical rockets. Based on NASA developments, the five-stage 7000-lb solid rocket assembly (Argo E-5) shown above, produced by Aerolab Development Corp., carries a 50-lb payload to an altitude of over 500 miles, at a cost of less than $1.00 per payload pound per mile of altitude. A number of these rockets took soundings as part of Project Argus.



These Russian photos show Lunik I (left) and its instrument package (reportedly weighing 796.5 lb) mounted on handling dollies. The instruments appear compact, but it is not known whether they are miniaturized. Such payloads represent an investment measured in tens of millions of dollars. Probe case has four antennas for transmission at 183.6 mc; long rod is hollow and contains a magnetometer on end. Instrument package contains transmitters for frequencies of 183.6 and 19.993 mc, two proton traps for sampling space, two piezoelectric gauges for micrometeor counts, an instrument to measure heavy nuclei of primary cosmic rays, and silver-zinc oxide and mercury-cell batteries.



Designing small space payloads

To obtain select scientific data at low cost—this is the aim of the miniaturized payloads designed to exploit the unique properties of outer space in controlled experiments now in planning stages

By R. G. McCarty

U.S. NAVAL ORDNANCE TEST STATION, CHINA LAKE, CALIF.

THE DISTINCT difference in size of Russian and American satellites and space probes has led the American press to point out, in a somewhat defensive vein, that our payloads at least excel their Soviet counterparts from the standpoint of miniaturization. That this point is to some extent appropriate is evidenced by the excellent work by James Van Allen and his associates in measuring radiation fields with very small instrument packages.

Advantages derived from small but sophisticated payloads are manifold. It is the purpose of this paper to advance two principles considered important, at least by the U.S. Naval Ordnance Test Station, in the design of outer space payload instruments. The first of these results in the requirement for small payloads; the second indicates one important way to achieve the required miniaturization and also to increase reliability.

For some time to come, we may expect that data gathered by extra-atmospheric experiments will reveal new and unanticipated physical phenomena. (The Van Allen radiation belt experiments and the NRL ultraviolet sounding rocket experiments are cases in point.) This data will suggest a multitude of follow-up experiments to exploit new knowledge. Each payload of a follow-up experiment will require an additional investment in propulsion.

The scientist is consequently faced with an alternative. On the one hand, he can build equipment to bracket all values of the many parameters of interest. If sufficient payload weight is allowed, he will then be able to gather and transmit the desired information. The degree of complexity required and, consequently, payload weight is strongly dependent upon the uncertainty about the data to be gathered.

His alternative is an approach commonly followed in laboratory investigations of nature. He can perform a series of experiments, starting with a cursory survey and then following up with successively more refined measurements. This procedure usually results in better measurements made more expeditiously. Since the range of experimental parameters becomes better and better known in the course of the experiment, the accuracy of the data can be continuously increased while limiting the complexity of the apparatus employed.

R. G. McCarty is project engineer for the NOTS lunar scanner program. After receiving B.S. (1949) and M.S. (1951) degrees in physics at Wayne State Univ., he worked for a period at NRL on radar, later accepted a fellowship from the Institute of Nuclear Studies for a year of study at Vanderbilt Univ., and then continued his studies at the Illinois Institute of Technology while working as a nuclear physicist at Armour Research Foundation. Since joining the NOTS staff in 1955, he has done research and engineering on infrared homing missiles, countermeasures, and, more recently, payloads for space research.

In space research, the propulsion expenditure becomes prodigious if payloads are heavy. Thus the second course of action is available only if the experiments are miniaturized, the weights kept low, and the rocket motors designed for reliability and easy launching. The second course of action—even when there are problems of payload miniaturization—is preferred by experiment designers at this station.

Granted that single experiment payloads of small weight are desirable, we now consider the second principle, which helps to achieve this goal. The principle is simply to exploit, early in the design of an experiment and its equipment, the unique properties of the space environment—high order vacuum, weightlessness, magnetic fields, solar radiation, frictionless bearings (in the appropriate sense), etc. —rather than to compensate for these properties at great expense.

Examples of some experiments made or being prepared at NOTS will serve to illustrate this principle.

One of the first space payload tasks undertaken at NOTS was the development of a scanner for the Air Force's lunar probes which would generate a picture of the back side of the moon. The terminal stages of the AF vehicles were spun to between two and three revolutions per second to achieve spin stabilization of the vehicle above the atmosphere. It seemed worthwhile to incorporate the spin and resultant gyroscopic stability into the design of the experiment. Hence the optical telescope was mounted perpendicular to the spin axis and allowed to sweep out a narrow circular strip scan.

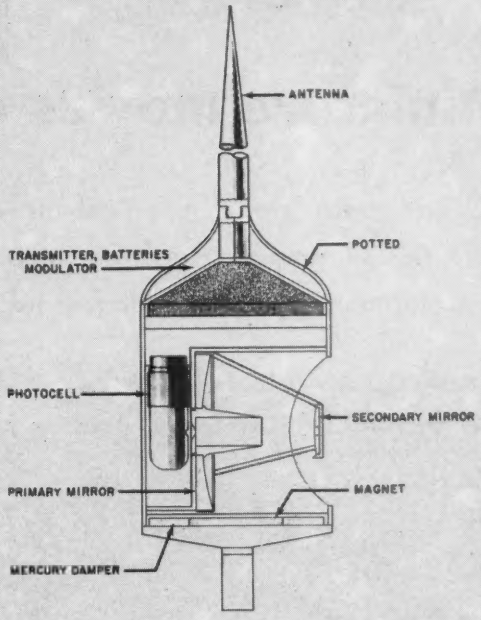
Generates Continuous Scans

Motion of the vehicle in orbit causes the scanning axis to advance, thereby generating continuous strip scans of a large area. Nutation induced during motor burnings are removed by a nutation damper. The damper, developed at NOTS, consists of a ring partially filled with mercury, and placed concentric with the spin axis and above the center of mass. The mercury revolves at a rate different than the spinning body while nutation exists but remains fixed relative to the body after damping the nutation. This damper, although quite simple, has been found to be extremely effective and works rapidly.

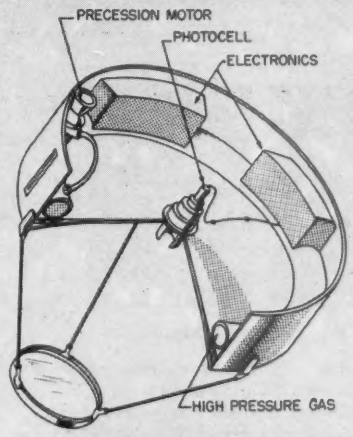
Utilization of this technique permitted us to design a system with no internal moving parts, which tend to decrease reliability and induce instabilities.

The top drawing at right illustrates a second scanner under development at this station. This scanner is to be used in a (CONTINUED ON PAGE 96)

Scanning Device for Sounding Rocket



Ground Controlled Precessible Telescope



Below, Pioneer I transmitter, an example of efficient design leading to light weight and compactness. Wrapping the output coil around the tube envelope eliminates need for special fixture to fasten and support the coil.

Miniature movies of the planets

The first space probes are likely to employ scanning systems which more closely resemble miniature computers than present-day TV equipment to make composite images of the moon and nearer planets

By Stuart C. Baker and John M. Kelso

SPACE TECHNOLOGY LABORATORIES, LOS ANGELES, CALIF.

WITH MAN'S initial reach toward neighboring planets comes the desire for pictures he has never seen—the other side of the moon, a closeup of a Martian "canal," a look at the small-scale cloud structure, if any, of Venus—without the obscuring effect of the earth's atmosphere.

Systems have been designed at Space Technology Labs to obtain such pictures with our first planetary probes. Briefly, these systems generate electrical signals, representing a desired picture, which are relayed to earth by a radio transmitter.

From the standpoint of scientific value, one would like to obtain images with better resolution than that obtained on earth with astronomical telescopes. Also, one would like a gray scale with a large number of discernible levels and, of course, very little "noise." Unfortunately, there are limitations of a practical nature which, in some cases, prevent fulfillment of these desires.

One limitation stems from the fact that power aboard a space probe comes at a high price in terms of battery or solar cell weight. Transmission over any but the most meager video bandwidths requires a transmitter of prohibitively high power. The consequence of small bandwidth is that the first pictures may be quite rudimentary. For instance, our first image of the moon's

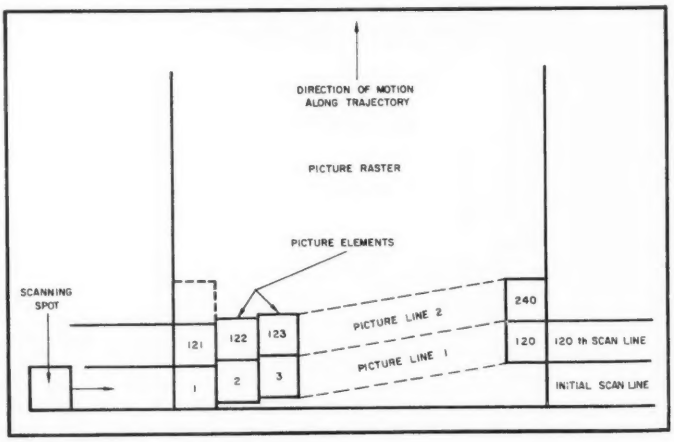
Baker

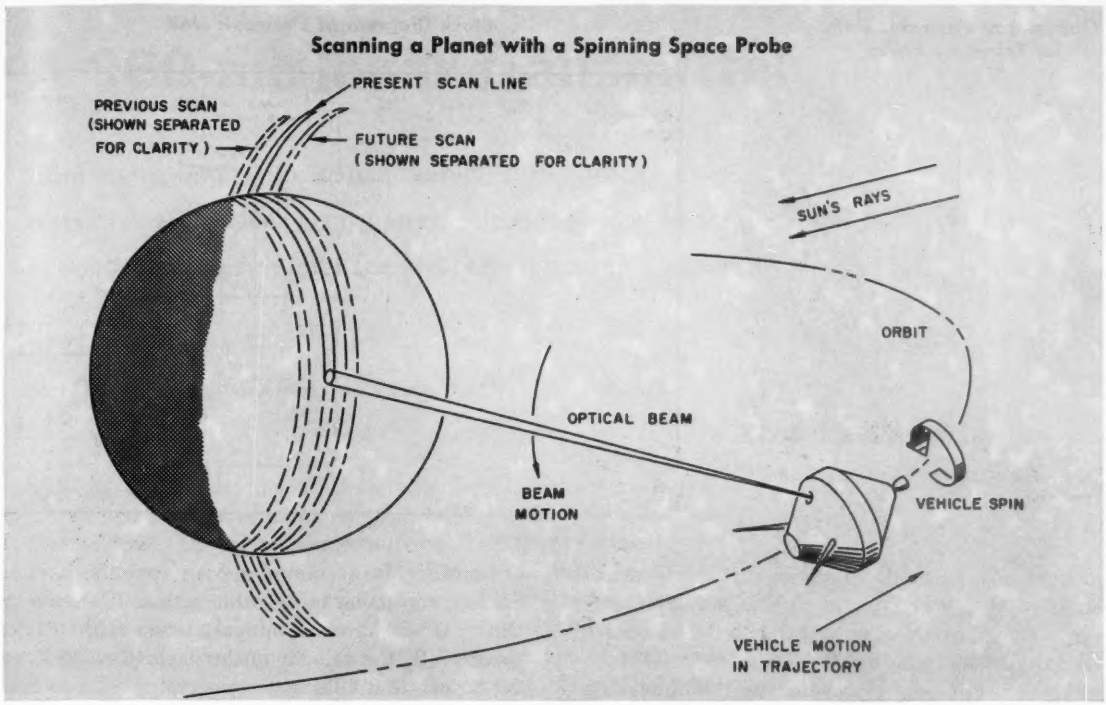
Kelso

Stuart C. Baker is a staff member of STL's Electronics Lab. He received a bachelor's degree in electrical engineering from Rensselaer Polytechnic Institute in 1953 and a master's degree in electrical engineering from MIT in 1955. His work at STL has been concerned with instrumentation for missile flight evaluation and, lately, scientific instruments for space probes.

John M. Kelso received a bachelor's degree in physics from Gettysburg College in 1943 and M.S. and Ph.D. degrees in physics in 1945 and 1949 from Pennsylvania State Univ., where he was an associate professor and member of its Ionosphere Research Lab until 1954. During this time, he spent a year as visiting professor at Chalmers Institute of Technology, Gothenburg, Sweden. Then after several years in operations research, he joined the staff of the Communications Div. of Ramo-Wooldridge, where he did systems engineering. Dr. Kelso has been a staff member of STL's Electronic Lab since 1957, working chiefly on space physics.

Generation of a Picture Raster





far side will quite likely show only larger features—a far cry from the resolution attained in pictures of the earthward side taken with telescopes here.

Other limitations are of a similar nature. The weight of an image system must be no more than several pounds, since present payloads themselves weigh so little. In addition, the primary power drawn by an image system must be small—typically, a few tenths of a watt. These two factors severely limit the choice of a system. Use of a high resolution image orthicon and large CRT or core memories for picture storage are precluded.

Still other limitations on image system operation arise from vehicle dynamics. The last stages, including payload, of the early planetary rockets will probably be spin-stabilized to reduce the complexity of the guidance system. If, as for previous space vehicles, spin rates of several revolutions per second are employed, shuttered image systems must be ruled out because of image blurring, unless shutter speeds in the order of a millisecond can be obtained. It is difficult to devise a mechanical shutter to operate at this speed and also to withstand missile launch and outer space environment.

Mechanical shutters are undesirable for another reason. Moving parts within a spin-stabilized space probe upset the moments of inertia of the vehicle, and hence tend to introduce precession and a change in spin rate. Even if rugged millisecond shutters could be constructed, and were feasible from the vehicle dynamics standpoint, as are electro-optic shutters, there are few optical field sensor devices that have both sufficient sensitivity and adequate storage time to retain an image during the lengthy process of transmitting the video information to earth. One of the few such field sensors is an image dissector which must be used in conjunction with a storage device. The disadvantages of this system are its weight and bulkiness and the need for high voltage.

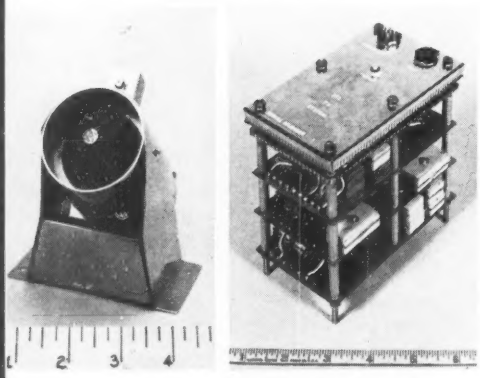
Eliminates Facsimile Systems

The fast shutter speed and "no moving parts" requirements are also sufficient to eliminate consideration of photographic facsimile systems in which a photograph is taken and the film processed automatically and then scanned slowly for transmission to earth.

An image system appearing more desirable is one which makes use of vehicle spin, rather than trying to operate in spite of it. Let's look at a system of this kind.

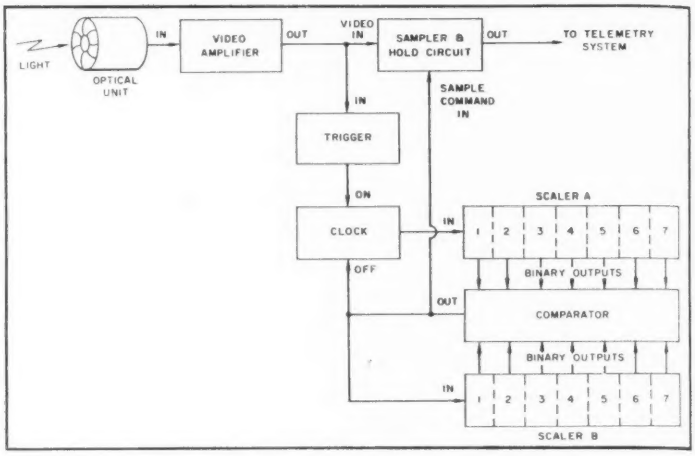
The motions of a planetary payload provide an unique opportunity for "built-in" scanning. Vehicle spin can furnish line scanning, and vehicle travel along its trajectory can produce frame scanning. Then one needs only a simple optical device, fixed in the vehicle, and designed to see only a small spot

Optical and Electronic Units for Planetary Probe



Note: Electronic unit (right) has cover removed.

Block Diagram of Electronic Unit



of light in a particular direction. It might consist simply of a photosensor and pinhole, although better performance would be obtained with the addition of focusing lenses or mirrors.

The "optical beam" provided by the optical system sweeps a full circle in space as the vehicle rotates. Furthermore, as the payload moves along the trajectory, the scanned circle moves forward. As a result, a helix is scanned. When this helix intersects a planet, lines are scanned across the surface by the optical beam, due to payload spin. As the vehicle moves around (or past) the planet, the scan lines gradually move across the planet until all the visible surface has been scanned. The sketch atop page 27 illustrates this procedure.

The output of the photosensor might be amplified and transmitted directly to the ground. Unfortunately, for typical trajectories, there are two drawbacks to direct transmission. First, the required bandwidth, although not as large as required for commercial television, is nevertheless too wide to make use of low bandwidth and hence low power transmitting systems. Bandwidths of kilocycles per second would be required, whereas available bandwidths are in the order of cycles per second. Second, successive line scans may overlap to a large extent, resulting in wasteful transmission of highly redundant information. In addition, since the optics sensor is looking at black space for a large portion of the spin revolution, the useful duty factor of the transmitter is reduced.

These factors lead to the conclusion that transmission of a complete line during each revolution is not required. In fact, with vehicle spin rates of several revolutions per second and typical planetary orbits, a picture of reasonable resolution can be obtained if only a single spot, or element, is sampled during each spin revolution.

Consider, for example, a 2-rps spinning payload circling the moon in an orbit with a 4000-mile radius. If we have an optical system with 0.5-deg beamwidth, the velocity of the payload along its orbit is such that adjacent, nonoverlapping scan lines occur about once every minute, or once every 120 spin revolutions. The middle 119 scan lines overlap the first and 120th, and therefore contain redundant video information. If, however, the brightness value of only one 0.5 by 0.5 deg element is transmitted during each spin revolution, and these elements are arranged next to each other, as shown on page 26, the result is a line containing 120 adjacent elements. One such line is obtained each 60 sec. Successive lines, each containing 120 elements, are taken to complete a raster. Since each element occupies 0.5 deg along a line, the line segment length subtends an angle of about 60 deg, which is slightly greater than that subtended by the lunar diameter.

Readout over Telemetry System

The voltage representing the brightness of a single element is read out over the telemetry system during one spin revolution. Hence, in 1.0 sec two voltage levels are transmitted, each of 0.5-sec duration. The fundamental frequency of this signal is 1 cps, and this frequency is suitable for transmission over narrowband telemetry systems.

Such an image transmission system is not strictly a facsimile system, since the picture is transmitted in real-time with no intermediate photographic or other process. Also, because of the low transmission rate and the sampled-scan process, it can hardly be called "television" in the everyday sense.

An image system of the (CONTINUED ON PAGE 104)

A 960-mc lunar transmitter

Communicating with space vehicles at great ranges will be possible with UHF transmitters drawing on latest advances in solid-state technology for high efficiency and minimum weight

By Leonard R. Malling

JET PROPULSION LABORATORY, PASADENA, CALIF.

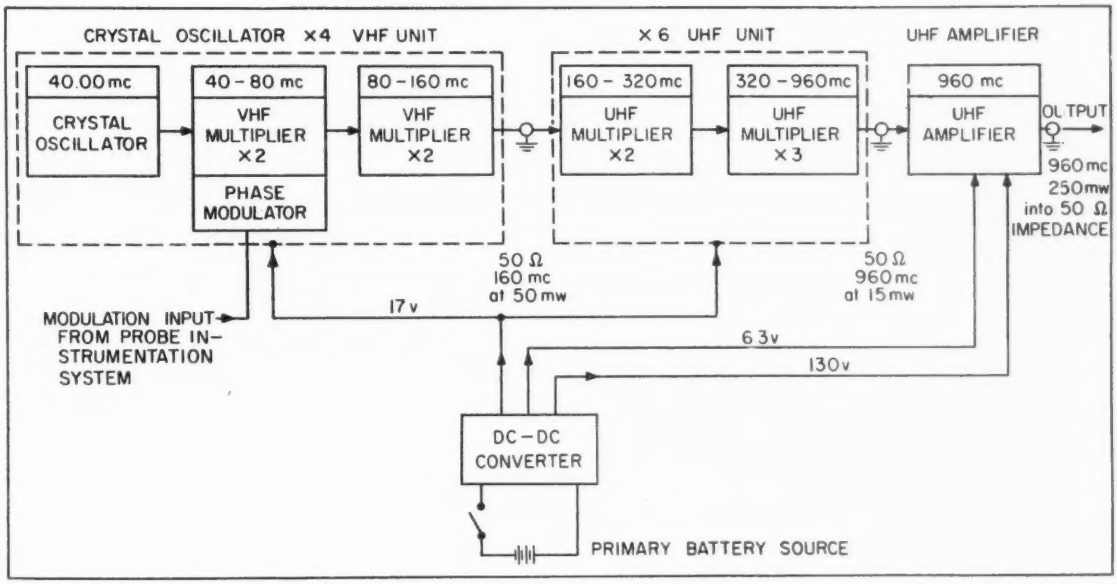
RECENT advances in solid-state technology have now made possible the design of highly efficient UHF (1000-mc) transmitters that will meet the specialized requirements of space research vehicles. This move from the VHF to the UHF band is highly desirable, since it allows extending greatly the range of noise-free communications with space probes.

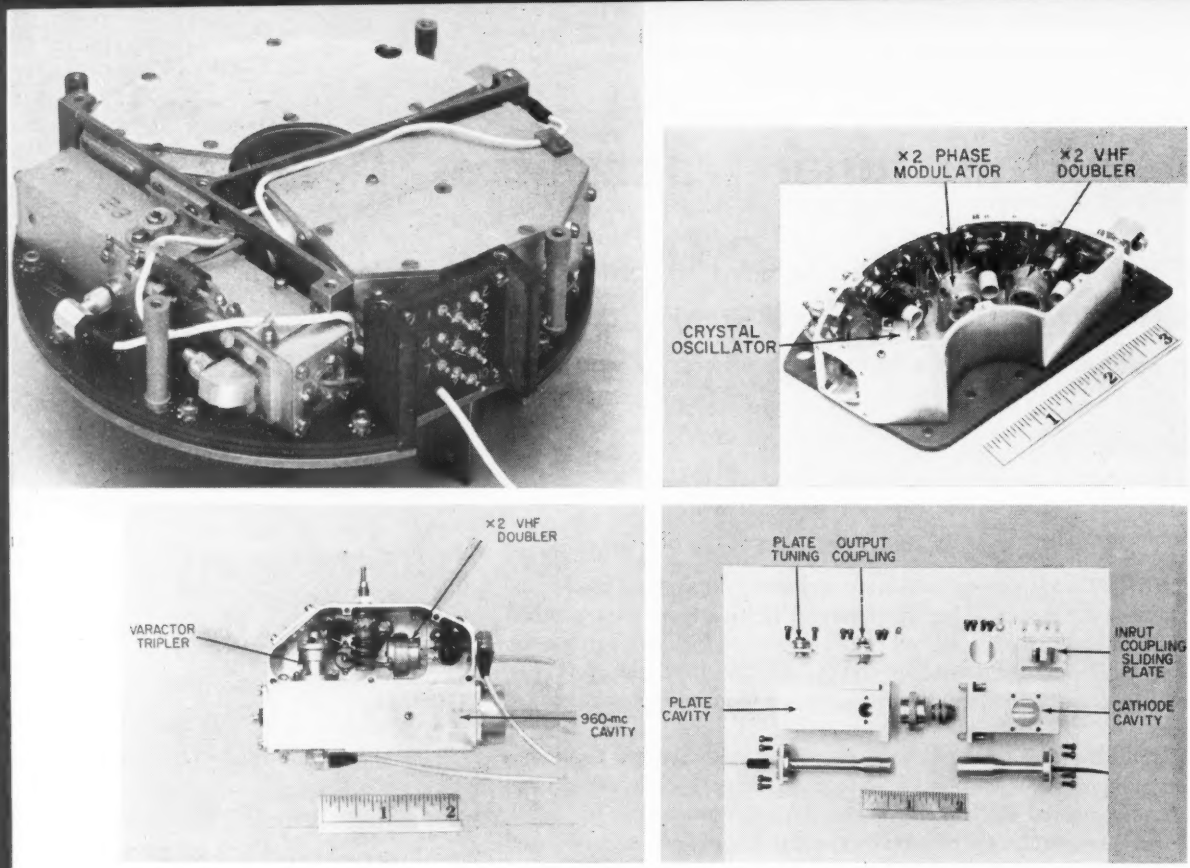
Typically, rocket-launched space experiments involve communication links that must operate in two phases: (1) The initial take-off and powered flight phase, when the transmitter is subjected to the intense vibration produced by the burning of rocket motors, and (2) a free-flight or coasting phase, when the payload is in a relatively unperturbed mechanical environment but a somewhat unpredictable and variable temperature environment. To withstand these environmental conditions, the transmitter must not only be highly efficient but also must be rugged, stable, and of minimum weight.

Fortunately, in view of the extreme ranges involved, a substantial reduction in transmitter radiated power in comparison to other com-

Leonard R. Malling graduated from Northampton Technical Institute, London, England, in 1931 and came to this country in 1938. For some 30 years he has done research and design engineering in such areas as radar, nuclear resonance, aircraft guidance, guided missiles, and space vehicles. He joined JPL as a senior research engineer in 1955.

TRANSMITTER BLOCK DIAGRAM



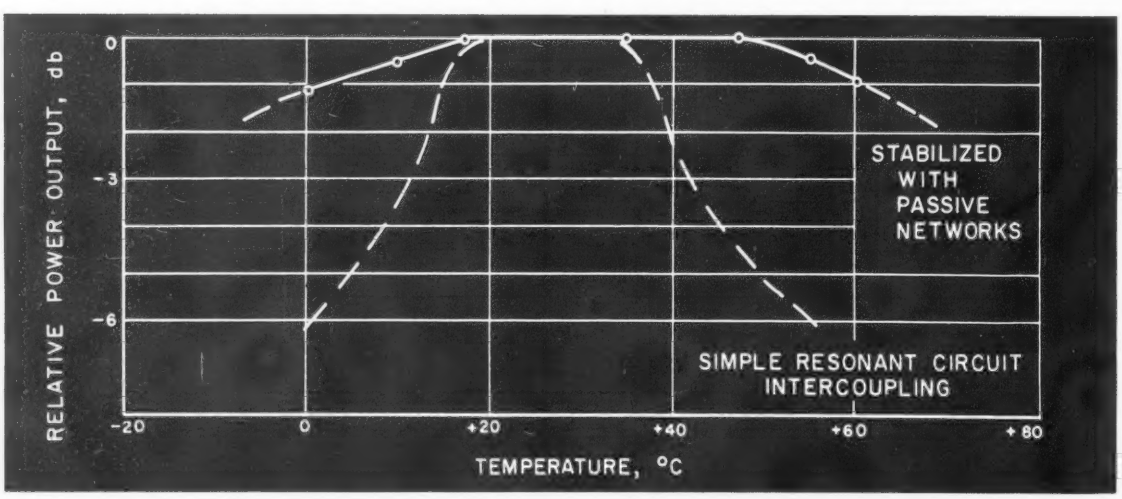


Transmitter (top left) and subassemblies: VHF unit (top right); X6 UHF unit (above left); and UHF amplifier (above right), disassembled to show construction.

munication systems is made possible by the use of the Microlock technique. With this system, range is extended by the use of sensitive narrowband, phase-coherent receivers. However, the phase and frequency stability of the transmitter must then be maintained within highly precise limits, particularly during the powered phases of flight. In spite of these stringent demands, UHF transmitters for operation with Microlock-type receivers have been constructed with a desired power output of $^1/_4$ watt at 960 mc, an over-all efficiency related to total DC power consumed of over 10 per cent, and a weight of less than one pound.

When these transmitters are used, scientific in-

PERFORMANCE OF TRANSMITTER WITH TEMPERATURE CHANGE



formation collected by a lunar probe must be put into a form suitable for transmission over the phase-coherent radio link. An efficient way of accomplishing this is to phase-modulate the transmitter with a number of subcarrier oscillators linked with the probe's instruments. The manner of this phase modulation can be seen in the block diagram of the UHF transmitter at the bottom of page 29.

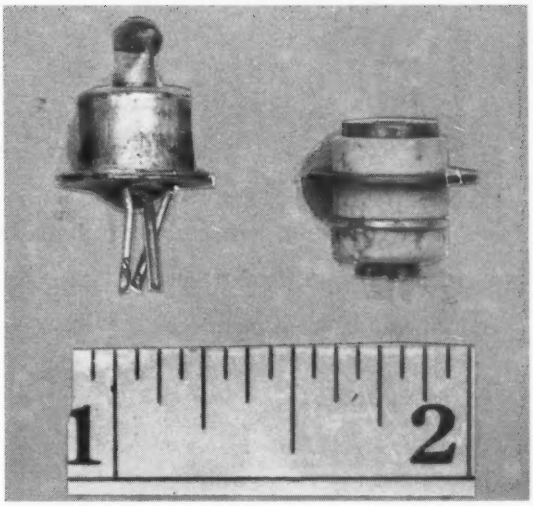
The particular combination of tube and transistors used has been based on research work that is leading to more efficient operation at the higher radio frequencies. For example, the maximum frequency of transistor operation is dependent upon the thickness of the base. Significant advances currently being made in the art of manufacturing and fabricating solid-state devices have led to the introduction of the diffused-base germanium transistor with base thickness of order of one micron which will operate at frequencies approaching several hundred mc. Another recently introduced solid-state device, the Varactor diode, permits operation at still higher frequencies with limits still to be ascertained. Thus, a transistorized VHF system using the diffused base transistor may be used to drive a solid-state Varactor diode as a frequency multiplier to generate power of the order of 20 mw at 960 mc.

Gives 10-to-1 Power Gains

Higher power is required for greater range. A recently introduced tube, the GE-7077—which has a grid-to-cathode spacing of $^1/_2$ mil, an over-all size comparable to the transistor (see photo at top right), and an economical heater power of 1.5 watts—gives power gains greater than 10 to 1. An advance in transistor techniques—the DC-to-DC converter—simplifies battery operation when the tube is combined with the transistors.

A photo on page 30 shows the VHF unit containing the oscillator and first doubler stages. The circuits using the germanium transistors, which are sensitive to temperature changes, have been stabilized by increasing the number of tuned elements beyond that normally required. This can be seen in the graph of power output and temperature characteristics for the transmitter on page 30. The transmitter frequency controlling element is a highly stable quartz crystal specifically ground for stable operation with vibration. The phase modulator is a solid-state, silicon junction diode.

The solid-state (X6) UHF unit contains a grounded base frequency doubler which develops approximately 50 mw of RF power at 320 mc with a collector efficiency of 25 per cent. This is followed by a silicon-diode (CONTINUED ON PAGE 104)



GF-45012 Transistor Compared with GE-7077 Vacuum Tube (right).

Efficiency and RF Output of the Three Sub-Units Comprising the Transmitter

Unit	Active device	Output frequency, mc	Total DC power, mw	RF power out, mw	Efficiency, %
VHF	transistor	160	250	50	20
UHF	transistor	960	180	15	8.5
UHF amplifier	vacuum tube	960	2100	250	11.5
Over-all transmitter	tube plus transistor	960	2530	250	10

Transmitter Performance Data

Carrier frequency	960 mc
Output power	0.25 watts
Short-term frequency stability, 15 min	1 part 10^7
Long-term frequency stability, ±5 C temperature range	1 part 10^6
Carrier-frequency accuracy	1 part 10^5
Power-output stability, 10 to 55 C	$\pm^1/_2$db
Modulation sensitivity	1 rad/volt rms
Modulation stability at β = 0.7 rad, 10 to 55 C	±2 deg
Maximum incidental phase modulation*	2 deg/g
Over-all weight	0.9 lb
Over-all size, 6-in. diam by 1-in. height	28 cu in.
Primary power input	2.5 watts
Transmitter efficiency	10%
Total operating time, 6.5-lb battery at 46 watt-hours/lb	120 hr

* Produced by mechanical vibration.

Piggyback missile research packages

Recently developed miniaturized instrument packages hitching rides in nose cones will cut the cost of important geophysical experiments while gathering new missile design data

Lt. Col. Gene M. DeGiacomo (USAF)

AIR FORCE CAMBRIDGE RESEARCH CENTER, BEDFORD, MASS.

IN THE EARLY days of our nation's ballistic missile test program, Air Force planners asked the research agencies within their realm to consider mounting scientific experiments aboard ICBM test rockets. This scheme was a natural, for such experiments feed back immediately into missile design and scientists are provided with vehicles whose gross performance outstrips stock research rockets. The promise of economy and mutual satisfaction bode well, in the long run at least, for this program.

As plans progressed, however, it became evident that an initially conceived "piggyback" package could not be tolerated. This package was to have ridden outside the body of the rocket and separate after motor burnout, flying thereafter as an entirely self-contained sensor–telemeter unit. It was deemed that this arrangement added a few too many problems to the already critically complex missile test program. So a substitute was sought.

Under the new rules, the experiment had to be physically tailored to available pockets within the rocket, had to make use of the missile's telemetry, and, in general, could in no way interfere with the ICBM test operation. The test nose cones offered the space and the telemetry, and ingeniously designed experiments provided the required simplicity.

Although many features of the piggyback package could not be realized with this arrangement, the simplicity and low cost of this manner of experimentation and the large number of available rides made the program particularly promising. Through the continued efforts of responsible offices at the Ballistics Missiles Div. of ARDC, it has been made possible only recently for scientists to incorporate important geophysical experiments as integral parts of test vehicles.

The task of incorporating environment sensors within a missile nose cone was a laborious one, calling for miniaturization of sensor design, fabrication of gear to withstand extreme conditions of induced environment, and mating of the sensor to a fixed power and telemetry system. Part of this task of design and development has been done. The Geophysics Research Directorate of AFCRC now has seven experiments being delivered to contractors for incorporation within the assembly line cones. Several more are in the planning stage.

The following experiments are immediately available for flight:

Lt. Col. Gene M. DeGiacomo is chief of the program planning branch of AFCRC's Geophysics Research Directorate, where he has seen duty since 1951. He received a B.S. in civil engineering from Lehigh Univ. in 1941 and B.S. and M.S. degrees in meteorology from New York Univ. in 1948 and 1949, respectively. He also attended service schools in aircraft engineering and electronics and radar during WW II. From 1949 to 1951, Col. DeGiacomo served in the Air Weather Service of MATS, in the AWS in Alaska, and on the Tropical Pacific Research Project in Hawaii.

Irradiance of nose cone ion sheath. A re-entering nose cone becomes surrounded with a dense sheath of ions. Radiometric (radio, IR, visual) detection and tracking of entry bodies are highly dependent upon both the intensity and spectral distribution of the radiation produced by this sheath. The experiment will gather data to study the radiation properties of the sheath and its composition. Thermal sensors utilizing photomultipliers will be used to give a measure of absolute irradiance in four broad adjacent spectral bands covering, in all, the region 1850 to 10,000 Å. Each flight will incorporate two instruments, each $5^1/_2$ in. sq by 5 in. deep and weighing about 2 lb.

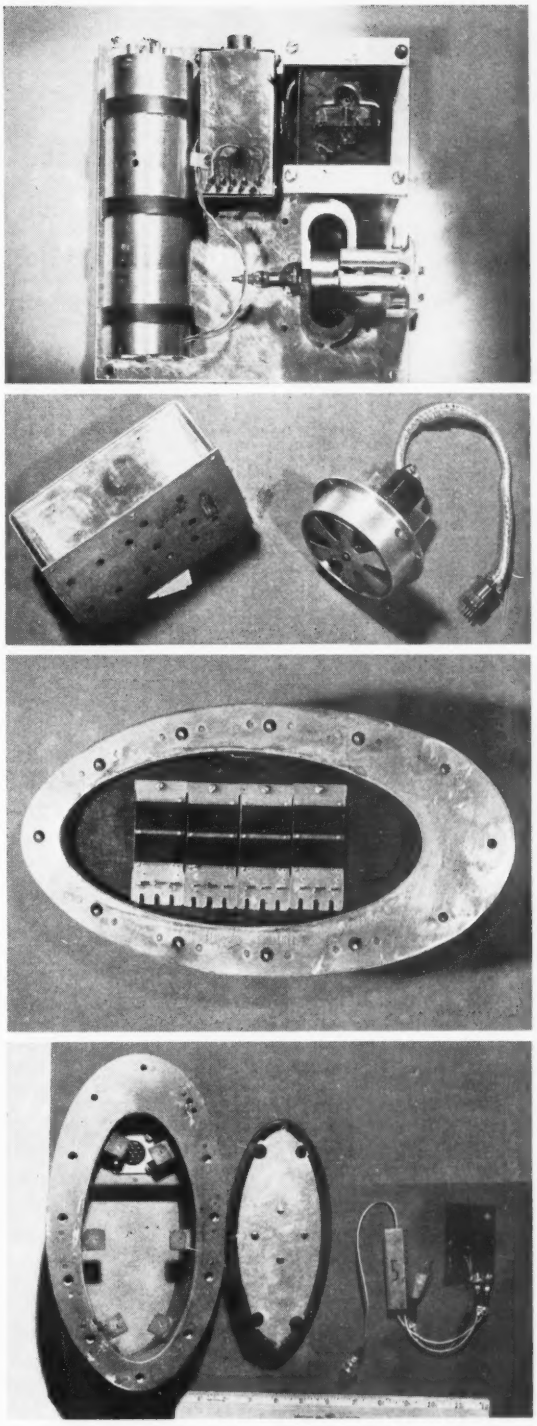
Density of extreme upper atmosphere. The density of the extreme upper atmosphere will be directly measured and compared with the indirect density determinations from satellite orbit data. The data so derived should help resolve the critical question as to whether all the drag experienced by a satellite is friction-produced. The experiment will involve a density gauge consisting essentially of a cold cathode ionization gauge utilizing high electric and magnetic fields for producing sufficient ionization at very low pressures. This ionization current will be amplified and the output fed to the telemetering system. The system, shown at right, consists of two units: A detector unit 5 by 5 by 3. 5 in. which requires a 1 in. opening to the outside atmosphere, and an amplifier and power supply system 13 by 4 by 3 in. Total weight of the two packages is 9 lb.

Electric field. Due to the different thermal velocities of ions and electrons striking its surface, the nose cone acquires an electric charge during its passage through the upper atmosphere. Photoemission from the surface of the vehicle also contributes to its charge.

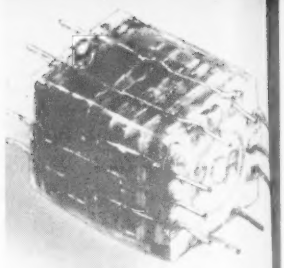
Source of Drag

It has been shown that the electric charge can be a source of drag. Since the charge on the surface of the nose cone modifies the ion and electron distribution in the vicinity of its surface, knowledge of the magnitude of the charge is also important when a nose cone is used for direct charge density and mass spectrometer measurements. From measurements of the external field, areas of entry of charged particles into the upper atmosphere and any regions of space charge along the trajectory can also be determined.

It is therefore of considerable scientific interest to measure the electric field at the surface of the nose cone, distinguishing the autogenous field due to the vehicle charge from that due to the ambient field. This can be accomplished, (CONTINUED ON PAGE 118)



Miniaturized piggyback instrument packages already designed for ballistic missile nose cones include (top to bottom) gauge for measuring air density directly in the extreme upper atmosphere; meter to measure the electric field at the surface of a nose cone during re-entry; grid detector for micrometeorites; and microphone detector for micrometeorites. The air-density gauge is roughly a 5-in. cube weighing about 2 lb.



Micromodules make their bow

Offering a parts density of 250,000 per cu ft, these tiny encapsulated electronic systems may significantly reduce payload sizes and weights

By H. J. Laiming and J. W. Knoll

RCA SURFACE COMMUNICATIONS DEPT., CAMDEN, N.J.

THERE can be no doubt as to the importance of further design effort in the miniaturization, with subsequent weight reduction, of missile and space vehicle payloads. Methods for scaling down existing conventional components have reached practical limits. Likewise, the encapsulation of parts into random size "potted" assemblies is already outmoded. A significant contribution to the miniaturization effort has been the development of the micromodule building block as a standardized medium for design integration.

The RCA micromodule program, supported by the Army Signal Corps, is planned to provide a new and broad production potential for fully reliable microminiature electronic equipment. Last February, the first live demonstration of a variety of ground communications equipment based on micromodules was presented to the Department of Defense. In this demonstration, the validity of the micromodule concept was clearly established, and emphasis was placed on the versatility of the concept, not only in the areas set forth in the present program, but also for future solid-state techniques.

Let's take a closer look at this concept, what it has led to in terms of hardware, and what it has to offer in terms of missile and satellite design.

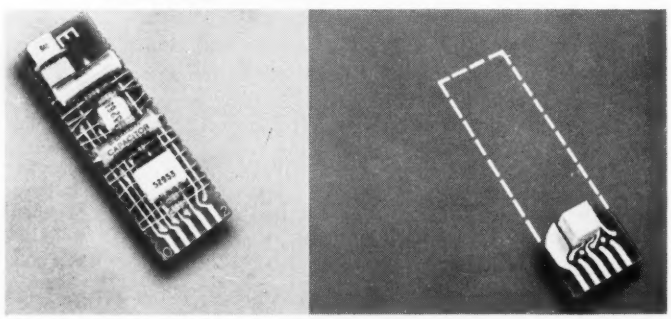
The mircomodule is an encapsulated assembly of tiny elements, each individually equivalent to one or more conventional com-

Laiming Knoll

H. J. Laiming graduated from Drexel Institute of Technology in 1934 with a B.S. in mechanical engineering. Upon joining RCA in 1935, he became active in engineering development, design, and management, and has since been responsible for numerous major programs on military radio equipment. In 1946 he was made an engineering staff assistant; in 1951 group leader; in 1953 manager of communications and sonar; and in 1956 manager of communications and military television. At present, he is the director of the RCA micromodule program.

J. W. Knoll received a B.S. in mechanical and aeronautical engineering from the Univ. of Pittsburgh in 1942, and subsequently did graduate work there. His engineering experience includes 13 years as a development engineer and supervisor of design at NADC, Johnsville, Pa. Later, with the Ballistic Missile Div. of Burroughs, as project engineer, technical coordinator, and assistant to the manager for mechanical design, he was active in the development of the Atlas guidance-computer system. He joined RCA in 1958, and is presently responsible for the design and development of micromodule packaging.

Conventional vs. Micromodule Pulse Generator



Size reduction: 20 to 1

ponents, such as resistors, capacitors, inductors, crystals, transistors, and diodes. The integration of the microelements in the module is such that a circuit function is represented and a structural unit is obtained.

The microelements comprising the module are standardized in the form of 0.310- by 0.310-in. wafers. Each wafer may represent the counterpart of one or more conventional components, containing, for example, combinations of active and passive elements.

Microelements are interconnected within a module by 12 riser wires terminating in end wafers. These end wafers provide circuit terminations and also serve as dams, or molds, for the entire module assembly. The resulting micromodule is a standardized building block approximately 0.350 by 0.350 in. high, the exact height varying with circuit function.

The micromodule gives high component density, a projective environment, reduced circuit interconnections, and compatibility with present-day production techniques—all with no compromise of sound electrical and mechanical design.

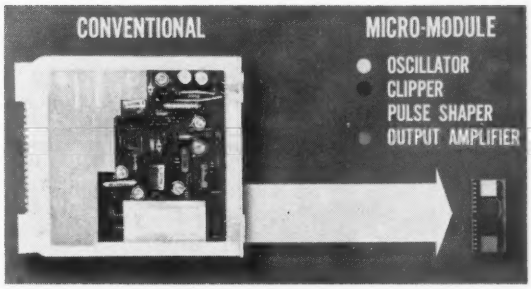
Used Integrated Approach

The micromodule concept from the first embraced future solid-state techniques, and particularly the so-called "integrated approach," which seek to accomplish in a single solid-state device or microcircuit the functions of many conventional components. Most basic solid-state microcircuit concepts assume a thin, flat shape and thus adapt readily to standard microelement geometry.

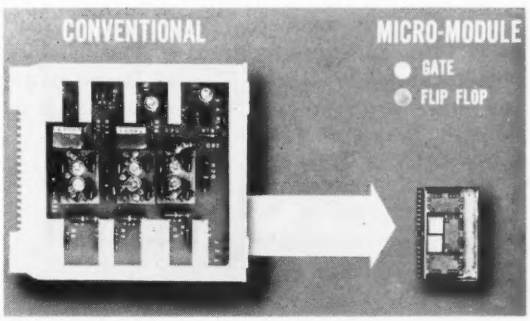
The micromodule concept permits the inclusion of solid-state devices in combination with microelements as fast as these new devices are developed. It does not demand total fulfillment of a complex function by a solid-state approach before the various parts can be applied to hardware. The most rapid exploitation of new techniques will come from hybrid approaches, using solid-state microcircuits in combination with standard microelements.

Under the present micromodule program, the integration of microelements into circuit functional building blocks has been realized. Micromodules representing RF, IF, audio, and digital circuit functions have been designed and fabricated. Operational capabilties of these micromodules in various military equipment have been demonstrated to DOD, while the integration capability of micromodules with conventional component assemblies and the adaptability of micromodules to complete equipment have been established.

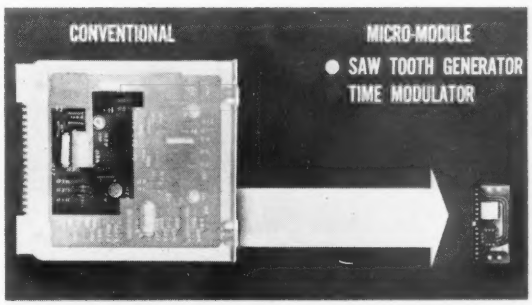
Micromodule Reduction of Time Division Multiplex Equipment



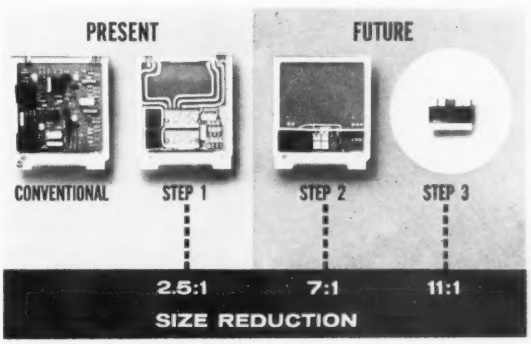
192-kc oscillator—5-to-1 size reduction



Binary divider—7-to-1 size reduction



Pulse-width modulator—6-to-1 size reduction



Dual-modulator subassembly—reductions as shown

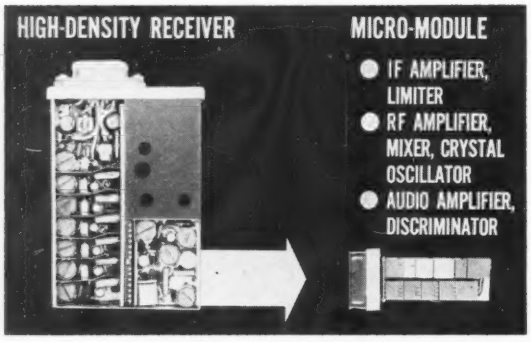
At the outset of this program, five definite task objectives were set forth:

1. Design integration of micromodules.
2. Demonstration of subassembly performance.
3. 10-to-1 size reduction, with an accompanying weight reduction.
4. Packaging density of 250,000 parts per cu ft, as compared to present miniaturization art, which can, at best, achieve part densities of 50,000–60,000 parts per cu ft.
5. Compatibility with service application, equipment integration, equipment production capability, and logistics support.

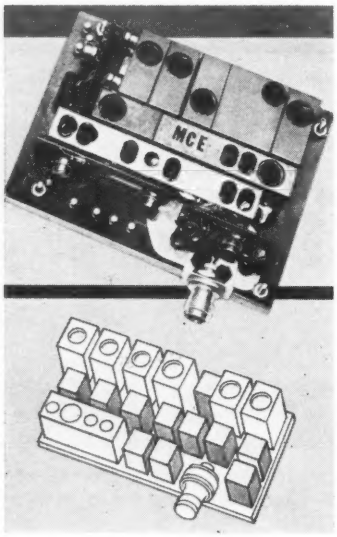
The implementation of the task objectives consisted of the selection of representative RF, IF, audio, and discriminator circuits applicable in a portable military transceiver; 192-K; oscillator, binary divider, and pulse-width modulator digital circuits applicable in 13-voice channel Time Division Multiplex equipment; and a pulse generator circuit applicable in a Coordinate Data Set.

One outcome of the program, dramatically showing its potential, is the pulse generator pictured on page 34. The micromodule realizes a size reduction in the order of 20 to 1, with a packaging density of 350,000 parts per cu ft. This micromodule indicates that the subassembly could embrace a greater portion of equipment function, thus necessitating a complete equipment redesign to exploit fully the advantages of micromodules.

High Density vs. Micromodule Receiver



Atlas-Score Command Receiver



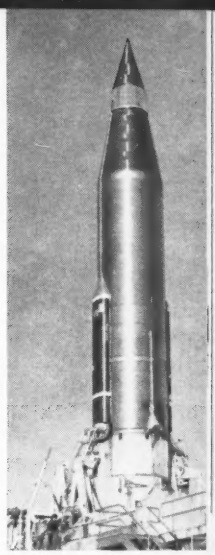
5-to-1 Size Reduction Achieved

Micromodule designs for digital circuitry applicable to the Time Division Multiplex equipment are well illustrated on page 35. The 192-kc timer package consists of an aggregate of four modules—oscillator, clipper, pulse shaper, and output amplifier—arranged as a single plug-in unit. Size reduction in the order of 5 to 1 and pa :kaging density of 240,000 parts per cu ft are obtained. The binary divider consists of eight modules of two types, flipflop and gate, again arranged as a single plug-in unit. Provision has been made in the design for the efficient removal of heat, since there is appreciable power dissipation in this circuit. This micromodule gives a size reduction in the order of 7 to 1 in spite of cooling requirements.

The pulse-width modulator consists of a sawtooth-generator and time-modulator modules in a single plug-in unit. Here, size reduction of 6 to 1 and packaging density of 240,000 parts per cu ft are obtained. The last figure in the series on page 35 shows further application of micromodule design to the entire dual modulator subassembly, with a final 11-to-1 size reduction.

These examples illustrate some of the versatility of micromodule plug-in subassemblies. Micromodules can also be adapted for use in conjunction with conventional components.

For example, the photo top left shows micromodule design of the receiver portion of the high density portable military transceiver. Eleven modules—RF amplifier, oscillator, mixer, IF amplifier, limiter, discriminator, and audio amplifier—are connected end to end in two rows, with the module configuration and connector assembled to the printed circuit board. All prime connections are to the basic printed circuit board, facilitating assembly and disassembly. The simple electrical layout with the necessary shielding gives a rigid mechanical structure. These factors contribute to reliability. Current models of this receiver show 5-to-1 size reduction and packaging density of 250,000 parts per cu ft. The compared equipment represents minimum size attainable with standard present-day components. Projecting this micromodule development to include the transmitter portion of the receiver still (CONTINUED ON PAGE 68)



Score—
First communications satellite

State-of-the-art approach was used in engineering the system presaging establishment of worldwide satellite communications network

By Marshall I. Davis and George N. Krassner

U.S. ARMY SIGNAL RESEARCH AND DEVELOPMENT LABORATORY, FT. MONMOUTH, N.J.

"THIS is the President of the United States speaking. Through the marvels of scientific advance my voice is coming to you from a satellite circling in outer space. My message is a simple one. Through this unique means. . ."

Thus began the message broadcast around the world from the communications package of the Atlas-Score earth satellite launched from Cape Canaveral Dec. 18, 1958. While orbiting the globe, the Score satellite relayed voice and teletype messages between ground stations separated by distances far too great for normal single-hop, line-of-sight transmission, or by terrain not accessible to intermediate repeater stations.

This may well herald a new era in the use of space. Military and commercial messages, as well as TV signals of the future, could be relayed between continents by fleets of satellites. This appears to be a practical solution to the growing traffic jam in virtually all of the radio frequency spectrum in ground-to-ground communications, especially in the high frequency band.

The Score project began early in July 1958 under ARPA sponsorship. A special task force of scientists, engineers, and technicians of the U.S. Army Signal R&D Lab was assigned to the project.

The system chosen for development was basically a "courier," or delayed-repeater, type. A message transmitted from the ground was stored in the satellite tape recorder. Upon proper commands, the message was transmitted down to another ground site as the satellite passed within line of sight of the second station. The design also permitted direct connection of the satellite transmitter and receiver, bypassing the tape recorder, for "real-time" (instantaneous) transmission between any two ground stations mutually "visible" to the satellite. The capacity of the system was one voice channel or seven 60 wpm teletype channels, frequency division multiplexed.

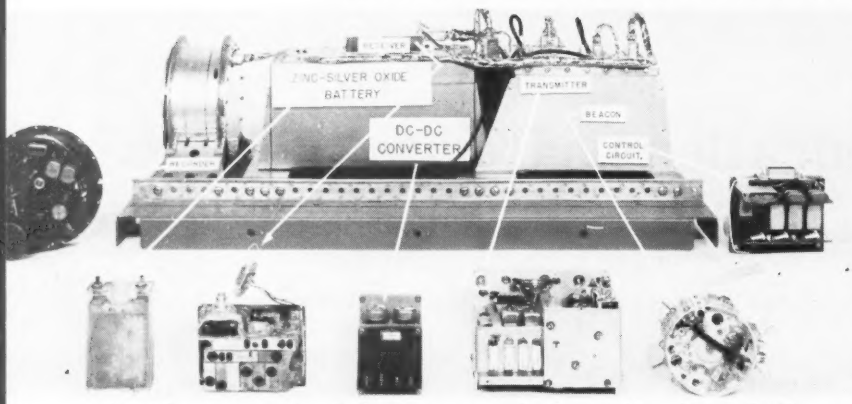
The orbit of the satellite, when plotted on a mercator projection of the earth, approximated a sine wave, between 32 deg N and S latitude. The altitude varied from an apogee of 913 miles to a perigee of 112 miles. For maximum communication time to stations within the U.S., the sites had to be located in roughly the lower third of the country. The four main communications ground stations were located at Prado Dam (near Los Angeles), Calif.; Ft. Huachuca, Ariz.; Ft. Sam Houston, San Antonio, Tex.;

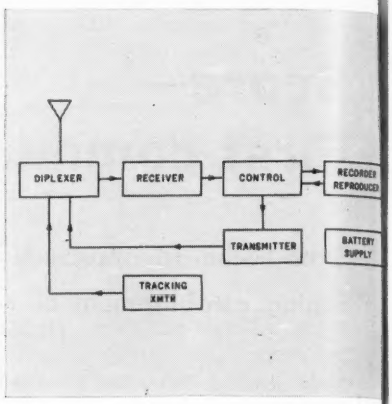
Davis Krassner

Marshall I. Davis is chief of the Advanced Developments Section of the Astro-Electronics Div. Previously, as assistant chief of the satellite-equipment section of the division, he was responsible for the design, coordination, and installation of the communications package for Project Score. He joined the Signal Lab in 1951 after receiving a bachelor's degree in electrical engineering from Northeastern Univ. In 1958 he received a master's degree in electrical engineering from Newark College.

George N. Krassner, a member of the technical staff of the Signal Lab's Astro-Electronics Div., was responsible for the initial system design and coordination for Project Score. He received a master's degree in electrical engineering from the Univ. of Michigan in 1951 and immediately thereafter joined the Signal Lab. He has worked mainly on the development of microwave communications and troposphere scatter systems, in part as chief of the satellite-equipment section of the Astro-Electronics Div.

SCORE COMPONENTS AND SYSTEM DIAGRAM





Note: Components are shown before they were potted and mounted in canisters on the Atlas.

and Ft. Stewart, Savannah, Ga. The map on page 39 indicates the path of the satellite during the first two orbits and the location of the ground stations.

A fifth station was set up at Cape Canaveral for prelaunch checkout, final countdown tests, and preliminary checks for the first few days in orbit. All station activities were coordinated by means of a high frequency interstation net using the AN/GRC-26 radio system, with control headquarters at the Signal Corps' satellite tracking station at Deal, N.J. Decisions to playback, record, attempt instantaneous transmission, etc., all emanated from the Deal control point.

The approach taken to design can be seen in the table of technical characteristics at left. Readily available military and commercial equipment, requiring minimum modification to meet these characteristics, suggested the use of VHF frequencies low enough to completely transistorize the receiver, yet high enough to avoid significant effects of cosmic noise and ionospheric propagation. The intermediate frequency bandwidth chosen was as narrow as possible consistent with deviation, maximum audio frequency, Doppler shift, and oscillator stability. A deviation ratio of 1.0 at 5 kc/s required passing only the first side band for reasonably distortion-free reception. The maximum Doppler frequency shift was calculated to be ± 4 kc/s, based on the predicted orbital velocity relative to the earth. The oscillator stability of the satellite components was expected to be ± 0.005 per cent.

Doppler frequency shift causes the RF carrier of the satellite transmitter to change frequency when observed at the ground station receiver. The same is also true of the ground station transmitter with respect to the satellite receiver. In the satellite, it caused the RF signal to vary up to 4 kc from the actual carrier frequency.

SCORE CHARACTERISTICS

Technical

	Satellite	Ground
Transmit frequency	132 mc/s, nominal	150 mc/s, nominal
Receive frequency	150 mc/s, nominal	132 mc/s, nominal
Power output	8 watts	1 kw
Noise figure	10 db	6 db
IF bandwidth	40 kc/s	40 kc/s
Audio bandwidth	0.3–5.0 kc/s	0.3–5.0 kc/s
Antenna gain*	—1 db	16 db at 150 mc/s

*Over isotropic

Components

	Weight	Size, (cu in.)	Power Drain, (Watts)
Receiver	0.75	39	0.24
Transmitter	2.5	101	51.3
Beacon	1.0	27	0.36
Control Unit	0.75	37	3.0*
Recorder	3.25	99	1.4
DC-DC Converter	1.0	19.2	—
Battery	21.0	175	—
Mount and hardware	14.5	—	—
Antenna system	54.0	—	—

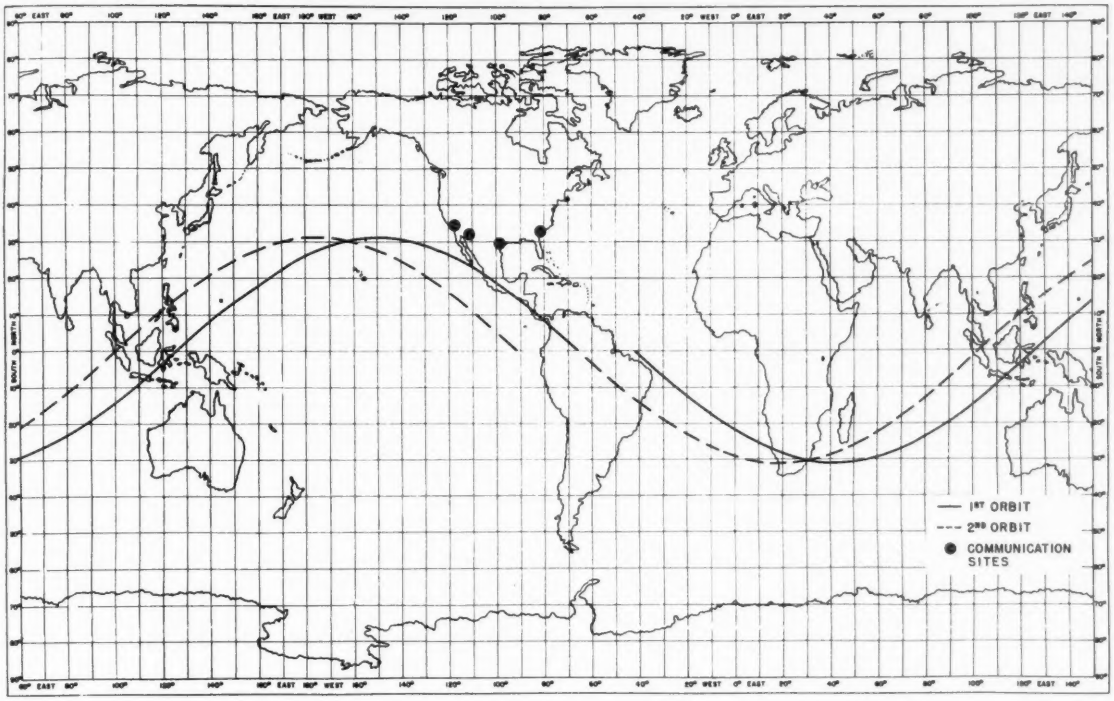
*Relay mode only.

System Analysis Made

A system analysis, using the familiar power balance equation, was made based upon an average path length (maximum slant range) to the satellite of 1000 miles. Miscellaneous losses taken account of included loss of transmission lines, duplexers and filters, and ring isolators in the satellite. Cosmic and solar noise were estimated to be about 5 db at 150 mc/s and 1 db at 130 mc/s.

A 10-db carrier-to-noise ratio was considered to be the minimum acceptable signal from the satellite.

FIRST TWO PASSES OF SCORE SATELLITE



A 19-lb margin was essential to compensate for nulls in the satellite antenna pattern and the expected drop in battery voltage.

The actual components used in the Score system are shown on page 38 before potting and mounting in canisters on this Atlas missile. The weight, size, and power drain of each of the major components are tabulated on page 38. The final payload totaled 142 lb, including redundancy of major components to provide additional reliability. Two identical systems were installed, operating on slightly different frequencies, to guard against failure of one system during launch or during the first few days of orbit.

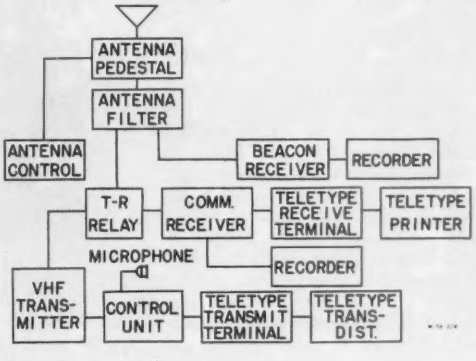
The satellite receiver was an FM "paging" receiver —the type often used by doctors and salesmen to receive telephone calls when away from their offices. A commercial model was modified extensively to increase its RF sensitivity and insure proper operation throughout the expected temperature range of 40 to 120 F. The addition of an RF stage and the use of selected transistors lowered the receiver "front end" noise figure to approximately 10 db. The receiver power drain under normal operation was 240 mw.

Since the receiver was completely transistorized, design requirements of the power supply were minimized by using a "battery save" device, based upon a transistorized relaxation oscillator circuit. The battery saver served as a switch in series with the receiver. It was energized, or in the normal "on" state, for a short time ($^1/_4$ sec) and in the "off" state for a longer time ($2^1/_2$ sec).

Upon reception of a command signal, the battery saver remained on and the receiver performed in its normal manner. When the signal disappeared, the battery saver resumed its function of pulsing the receiver on and off. Thus, the receiving equipment in the satellite was at all times able to detect a command from the ground without appreciable delay, yet power drain was reduced approximately 90 per cent during the standby period.

The transmitter utilized (CONTINUED ON PAGE 88)

DIAGRAM OF GROUND STATION



Microminiaturization in a space vehicle frequency standard

Modular microminiaturized components meet military design requirements while offering flexibility for space vehicle applications, both in function and precision manufacturing

By Patrick E. Lannan

DESIGNERS FOR INDUSTRY, INC., CLEVELAND, OHIO

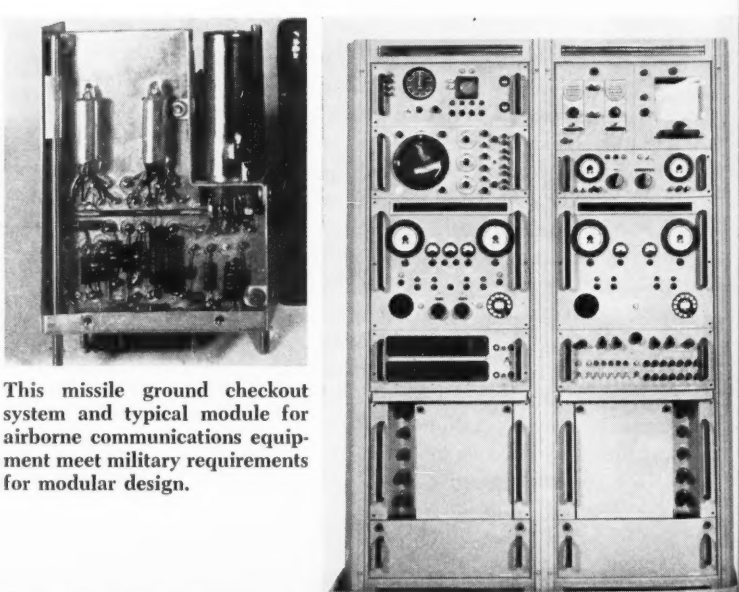
IN THE DESIGN and packaging of military equipment many a philosophy has been established that a module must satisfy certain requirements, which might be summarized as follows:

It must perform a complete function.
Its functions must be definable.
Its performance must be easily tested and evaluated.
It must use reliable MIL standard components.
It must be repairable at higher repair echelons.

With equipment designed to these few rules, first and second echelon personnel can easily locate a defective module, replace it, and continue an operation, while a third or fourth echelon can locate the exact failure and repair the module under more favorable conditions.

The panel-chassis shown below satisfies these requirements in the ground checkout system for a missile guidance component called the lateral and range computer. Each panel has a definite function. In some cases, an individual panel can be divided into three submodules.

Patrick E. Lannan is vice-president of the Research Div. and member of the board of directors for Designers for Industry. Educated at Syracuse Univ., Rochester Institute of Technology, and the Univ. of Rochester, his background includes supervision of design and development for Stromberg-Carlson. At Designers for Industry he has contributed to the design and development of missile guidance systems, various electromechanical equipment, subminiature receivers, and the Vanguard master sequence controller.



This missile ground checkout system and typical module for airborne communications equipment meet military requirements for modular design.

The figure at top right shows a typical module that satisfies these requirements in certain aircraft communications equipment. The printed circuit-board acts as the web in a channel. By serving the dual function of a mounting board and stiffening member, the board saves considerable weight. Another feature of this module is the cutout in the bottom, which allows cooling air from the distributor to pass along the plug and through the module.

With the advent of microminiaturization, which depends in good part on wide use of transistors and associated tiny components, concepts of modules and modular design techniques have of course changed, yet they have kept to the outlined design requirements to a noticeable degree. A brief look at the design of a microminiaturized secondary-frequency standard originally designed as part of the pitch programmer and sequencer for a satellite launching vehicle will serve to illustrate this point.

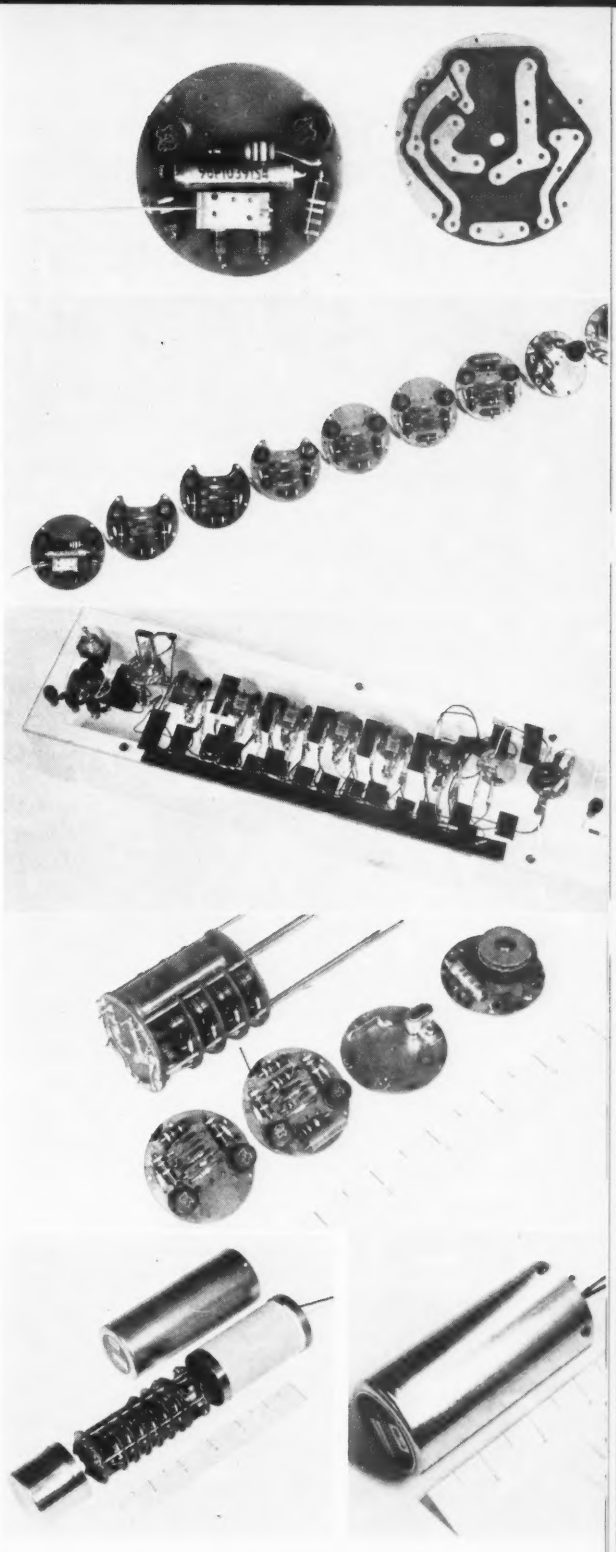
The frequency accuracy was based on a crystal whose resonant frequency was above the vibration spectrum of the launch vehicle. The frequency chosen was 25,600 cps, and the output of the crystal oscillator drove six binary dividers. The resultant 400-cps square-wave output was then amplified and shaped into a sine wave in two output stages.

Design Required 16 Transistors

This design required 16 transistors—two in the multivibrator-type crystal-controlled oscillator, two in each binary circuit, and two in the output stages. Efficient units reduced to "Tinker Toy" looking construction, but each wafer was a complete circuit and the circuit elements were standard stock components rather than printed capacitors and resistors.

The top figure at right shows the oscillator wafer both before and after mounting the circuit elements. The wafer is a copper laminated board which has the circuit wiring pattern etched on it and punched to size and punched to accept the element leads. The assembled unit appears this way after the pretested and prepared components are inserted. All the elements are hand-soldered, and a large amount of liquid flux is used as a heat sink to protect the transistors. After in-process quality control inspection, the unit is ready for testing in assembly jigs.

The next picture in the series shows the oscillator, six identical binary dividers, and the two output wafers; and the following one shows an assembly jig for testing the complete assembly as an entity prior to stacking. This illustrates one of the advantages to this type of micromodular construction. Since each wafer is a complete circuit, and there are nine wafers, it is advisable to conduct final assembly tests prior (CONTINUED ON PAGE 110)



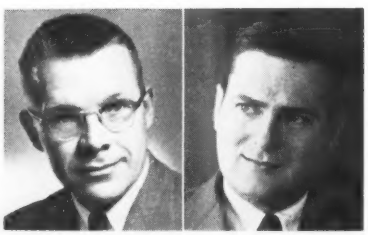
Micromodular components and steps in frequency standard assembly: Top to bottom, oscillator wafer (a "module") before and after mounting elements; all of the system micromodules; test jig; method of assembly, showing multipurpose support rods; assembly with heating sheath (white, slightly ribbed tube) and packaging cans; and, finally, "black box."

Miniaturized digital computing systems

A recent development, the miniaturized large capacity high speed digital computer will allow precise control of advanced aircraft and space vehicles

By Frederic A. Foss and Robert E. Lyons

IBM MILITARY PRODUCTS DIV., OWEGO, N.Y.



Foss Lyons

Frederic A. Foss is a senior engineer and manager of systems research for the IBM Military Products Div. He received a B.S. in electrical engineering from Tufts College in 1944 and an M.S. and another advanced degree in electrical engineering from MIT in 1948 and 1950, respectively. Since joining IBM in 1950, he has worked on logic and circuit design of advanced commercial data processors; analyses and system studies for the MA-2 project; as project head in charge of systems research for Dinaboc; and, recently, design and simulation of real-time control systems for advanced weapons and guidance.

Robert E. Lyons is a staff engineer at the Military Products Div., currently working on its advanced guidance program. He received B.S. and M.S. degrees in electrical engineering from MIT and the Univ. of Maryland, respectively, in 1950 and 1953, and an advanced degree from MIT, as an NSA fellow, in 1956. As an officer, and later in civilian status, he worked on large digital computers for NSA, where, before returning to MIT, he became a division head in charge of engineering maintenance of all NSA's large computers. He joined IBM in July 1958.

CONTROL of radically new air vehicles constitutes a challenge of the first magnitude to digital computer engineers. In terms of number of operations per second, for example, it seems likely that an increase by a factor of five or more will be required above the 16,000 operations per second capacity of airborne equipment being developed currently. This estimate is based on the guidance needs of a semi-orbital rocket bomber which will require, among other things, a rapid command rate, precise navigation to conserve fuel, elaborate operator displays, and complex data processing techniques to assist in solving the difficult problem of terrain sensing. These significant improvements over present guidance techniques must be adapted to a distinctly foreign environment, which may include a radioactive belt. Very long mission times, in an environment that precludes inflight maintenance, are also anticipated.

In spite of the difficulty of the problem, computer components, circuits, and logic appear equal to the task. While aircraft speeds have been increasing by a factor of 4 in the past several years, computer capacities (in operations per second) have increased by a factor of 16, and another factor of 10 is envisaged within the next few years.

Offers Preview of the Future

Contemporary airborne digital control systems offer a preview of this future. They mark a distinct advance in the computer technology, and are of interest for this alone. Let us look at present digital systems.

A few years ago, airborne control systems employed only analog techniques. Recently, however, digital techniques found in large-scale computers have been adapted to airborne systems. To accomplish this, it has been necessary to develop highly compact, general purpose digital computing equipment which can function compatibly with a variety of sensor and control devices.

The airborne computer operates as a central data processor in various control loops and provides a continuous flow of answers or corrections to guide a vehicle along a prescribed course

and to release a weapon at a predetermined instant.

The basic differences between the airborne digital computer and the ground data processor exist in the methods of instrumentation and in the fact that an airborne system must function in real-time while, generally speaking, the ground data processor operates independent of time. An additional factor which places severe restrictions on the airborne computer designer is the extreme environment to which his equipment will be exposed.

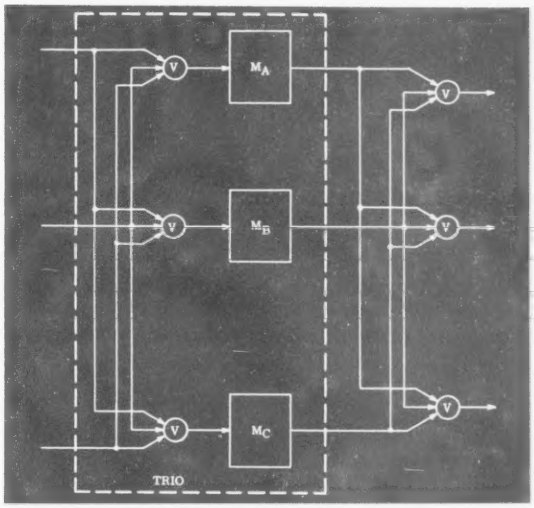
The real-time control application of a digital computer implies the processing of information in relation to the instant it is generated. In an airborne system, the computer inputs are continually changing and, therefore, will have a different effect on the computation depending on the time they are sampled by the computer. By periodically sampling each input at a rate compatible with the control problem, a semblance of real-time control is achieved. The difficulty of achieving a real-time control by digital techniques lies with the fact that the computer must be responsive to analog information, a situation uncommon in digital data processing systems. This problem has been solved by special analog-to-digital and digital-to-analog conversion devices.

Designs Are Diversified

The engineering design of an airborne digital computer concerns itself with three major areas—logical circuitry, memory devices, and input-output equipment. However, the different engineering designs which have been developed to date are as diversified as the many logical combinations in which these basic computer elements can be employed. To provide a common basis for discussion in the major design areas, we will refer to a contemporary airborne digital computer known as Dinaboc (Digital Navigation Bombing Computer), which IBM developed to determine the feasibility of placing a large capacity digital computer into aircraft. Because Dinaboc reflects the many advances necessary for airborne applications, and at the same time indicates the additional complexity required for a manned system, it represents a typical cross-section of airborne digital computer technology.

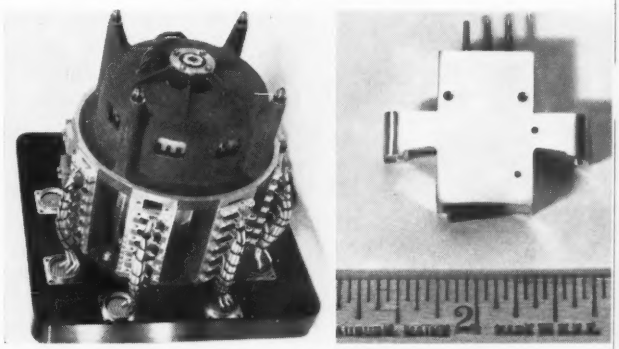
Dinaboc may be described as a general purpose, stored program, digital data processing control computer. It employs magnetic drum storage and transistor-diode logical circuits to instrument 20 binary digit arithmetic. The Dinaboc computer is equivalent to two magnetic drum computers operating in parallel and synchronized by common timing circuits. It has dual arithmetic elements and program control units; common input-output, data, and instruction tracks on a single (CONTINUED ON PAGE 54)

Triple Modular Redundant Configuration

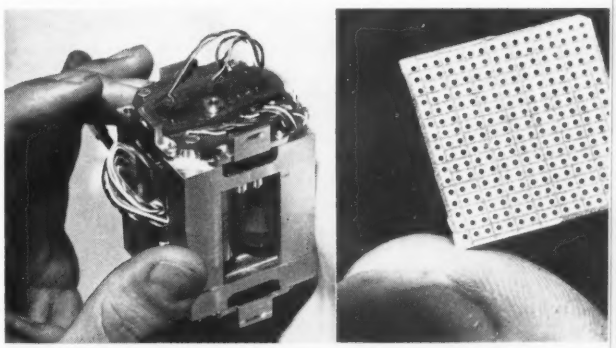


The computer will function properly as long as two out of three of the modules of each trio continue to function. The failure of a voting circuit (V) is equivalent to failure of the module that it drives.

Dinaboc Components



Left, magnetic storage drum of 100,000-bit capacity is 9 in. in diam and weighs only 12 lb. Right, air-floated magnetic read-write head automatically adjusts to changing contour of memory drum.



Left, miniature analog-to-digital converter permits shaft-to-digital shift by virtue of modular construction and unambiguous codes. Right, stacked ferrite apertured memory plates like this increase computing speeds.

Beyond microminiaturization: Integrated electronics

Research on microminiaturized multipurpose components employing inhomogenous solid-state materials may lead to space age electronic systems that will rival the human brain in complexity, volume, and power consumption

By Harry Kihn

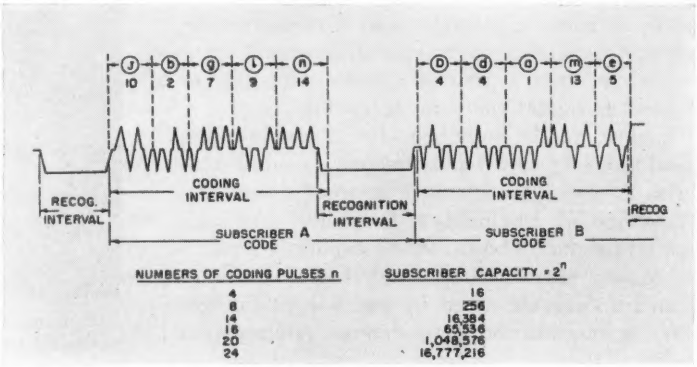
RCA LABORATORIES, PRINCETON, N.J.

Harry Kihn is an RCA Labs staff member, currently directing research there on pulse-code and digital communication and computer systems and on related military space equipment. After receiving a B.S. in electrical engineering from Cooper Union in 1934, he spent several years working on power tubes, receivers, electromechanical systems, and UHF signal generators in the industry before joining RCA in 1939. He became an RCA Labs staff member with its formation. With RCA he has done research and design engineering on a wide range of electronic components and systems—microwave receivers, frequency modulated radar, early television, teleran, compatible color television, high resolution radar, data transmission networks, etc. In 1952 he received an M.S. in electrical engineering from the Univ. of Pennsylvania. He holds more than 15 patents and has a number pending in many areas of radio and other electronic systems.

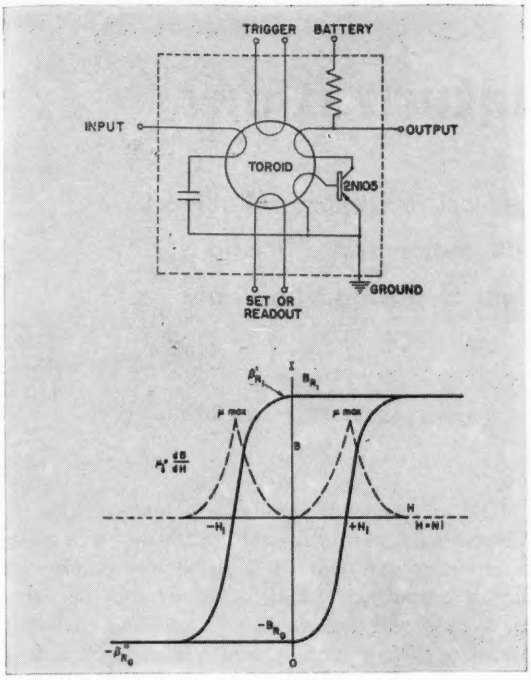
THE TREND toward miniaturization of electronic and mechanical components for communication, airborne navigation devices, and electronic consumer products was increasingly rapid even before the launching of the first earth satellite. One of the early monumental accomplishments in miniaturized reliable systems was the development of the proximity fuze during WWII. Rationalization of simplified system concepts and development of extremely small vacuum tubes, circuit elements, battery supplies, and antennas were combined to make a device which had a major influence on the outcome of the war. This device, because of requirements of reliability and operation under extremes of acceleration, illustrated the need of departure from merely a reduction of size, weight, and power requirements of then existing components.

Little was done in the early postwar era, except for such technique developments as "Tinker Toy" and the development of printed circuitry, largely because of the absence of the key element—a microminiature transducer.

It was the invention of the junction transistor and the consequent rapid development of a host of solid-state devices which set the stage for the great revolution in microminiaturization which we are now



Modulation waveforms of two subscribers' codes in time sequence.



One stage of the shift register used in the Megacoder.

witnessing. Here was a device capable of performing all the functions of the versatile vacuum tube with a small fraction of its volume, power consumption, and required operating voltage, and having, moreover, extreme ruggedness and the capability of "bidirectional" current flow, as in the "complementary" mode of operation.

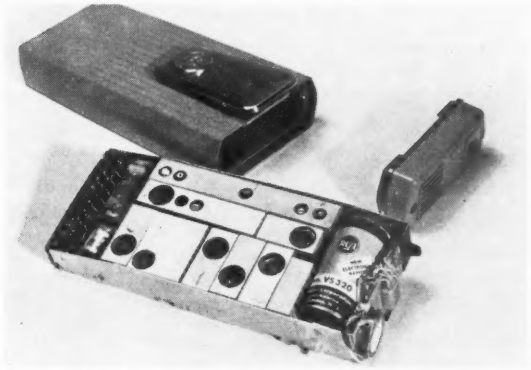
The rapid development of transistor and other solid-state oscillators, multivibrators, waveform generators, counters, and computer elements followed rapidly. These in turn produced radical developments in resistive, capacitative, and inductive components in microminiature form. New developments in high dielectric constant titanates for capacitors, evaporated metallic films for resistors, and high permeability ferrites made possible components commensurate in size and ruggedness with the transistor itself.

These developments have been extensively exploited in the consumer product field in the form of personalized receivers and transmitters, mobile communications, miniatur- (CONTINUED ON PAGE 126)

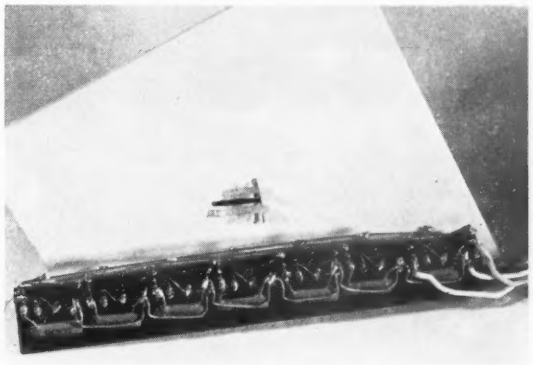
The Trend of Microminiaturization

Period	Technique	Functions/cu ft
1950–1960	Optimum miniaturization	5×10^4
1960 →	Micromodule	5×10^5
1965 (?) →	Integrated electronics	$\sim 10^5$

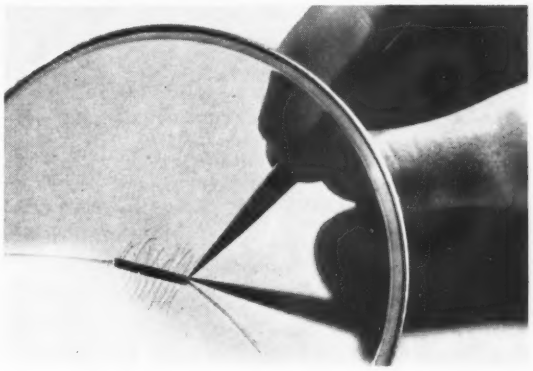
The modularized Megacoder.



Megacoder incorporated in a RCA-CPC-RI receiver.



Above, miniaturized as compared with integrated shift register, which is also magnified below.



What price microminiaturization?

Providing adequate propulsion capability may prove a more reliable and less costly means of carrying out many major space missions than attempting to minimize the size and weight of payload packages

By David A. Young

ADVANCED RESEARCH PROJECTS DIVISION, THE INSTITUTE FOR DEFENSE ANALYSES, WASHINGTON, D.C.

David A. Young has for the past year been chief of the Space Technology Branch of the ARPA Div. of IDA. In this capacity, he has been responsible for program evaluation and technical assistance to ARPA on the U.S. military space program. A 1942 Cal-Tech graduate, he was with Aerojet from 1942 to 1957, serving as project engineer on liquid rocket JATO units (1942–44); chief, Rocket Physics Dept., Research Div., in charge of research on liquid rocket engines and components (1944–50); principal engineer in the Development Dept., Liquid Engine Div. (1950–53); assistant chief engineer, Production Development Div., Liquid Engine Div., responsible for design and development of nonrocket projects (1953–55); and assistant chief engineer, Nuclear Projects Dept., Liquid Engine Div., in charge of nuclear rocket design and development under the Rover program (1955–57). Prior to joining IDA, he was an engineering consultant specializing in liquid rocket powerplant design and development. A longtime member of ARS, he received the ARS Robert H. Goddard Memorial Award in 1953.

ANY DISCUSSION of payloads and microminiaturization in terms of the present and near-future state of the art must inevitably answer two important questions. Is it better to minimize the payload, or maximize propulsion? And, assuming that we have this choice, which method will provide us with greater *reliability*?

Before we can answer these questions, however, a quick look at our present propulsion capability is in order.

Not too many years ago, rocket men were fond of saying that only infantrymen and rockets could carry nothing larger than 30-lb payloads. Today, this saying should probably be modified to read "only infantrymen and deep space probes," for the plain truth of the matter is that we now have the capability to put quite sizable payloads in space. As Herbert York, former chief scientist of ARPA and now DOD director of research and engineering, has noted, the maximum useful payload we can put into a relatively low satellite orbit today is about 4000 lb. By 1960–62, this figure will have risen to about 8000 lb, by 1962–64 to some 20,000 lb, and by 1964–68 to somewhere in the neighborhood of 50,000 lb.

With a propulsion capability of this order, payload microminiaturization may not be quite so important as is generally believed. Some future missions will, of course, require the smallest possible payload packages. However, this is no reason to assume that all payloads must be miniaturized, and Dr. York's rundown on how much propulsion capacity will be available in the not-too-distant future provides some food for thought for those to whom making smaller, lighter, and more compact electronic components has become an end in itself.

Payloads Vary with Mission

But just what types of payloads are we discussing? Actually, there are several different types, varying in accordance with the mission to be performed. Obviously, payloads required for deep space missions are likely to be quite different from, and will be more critical of weight than, those used in earth satellite missions or in exploring cislunar space. Microminiaturization may be a considerable asset, and even a necessity, for these same deep space missions.

For example, if we are talking about soft landings on Mars or Venus, even the propulsion capability we will have five years from

now may be insufficient to handle a relatively large payload, say of the order of 3000–4000 lb. For missions of this type, microminiaturization is important, and efforts aimed at producing components which are smaller, weigh less and take up less room than those available today will serve to greatly increase the useful returns of the experiment.

There are even some missions in near space which may require miniaturized payload packages. For example, NASA's four-stage solid propellant Scout, a relatively low cost, all-purpose vehicle, is expected to be capable of putting payloads of only about 150 lb in orbit, and here microminiaturization would be vital to the successful accomplishment of many types of missions.

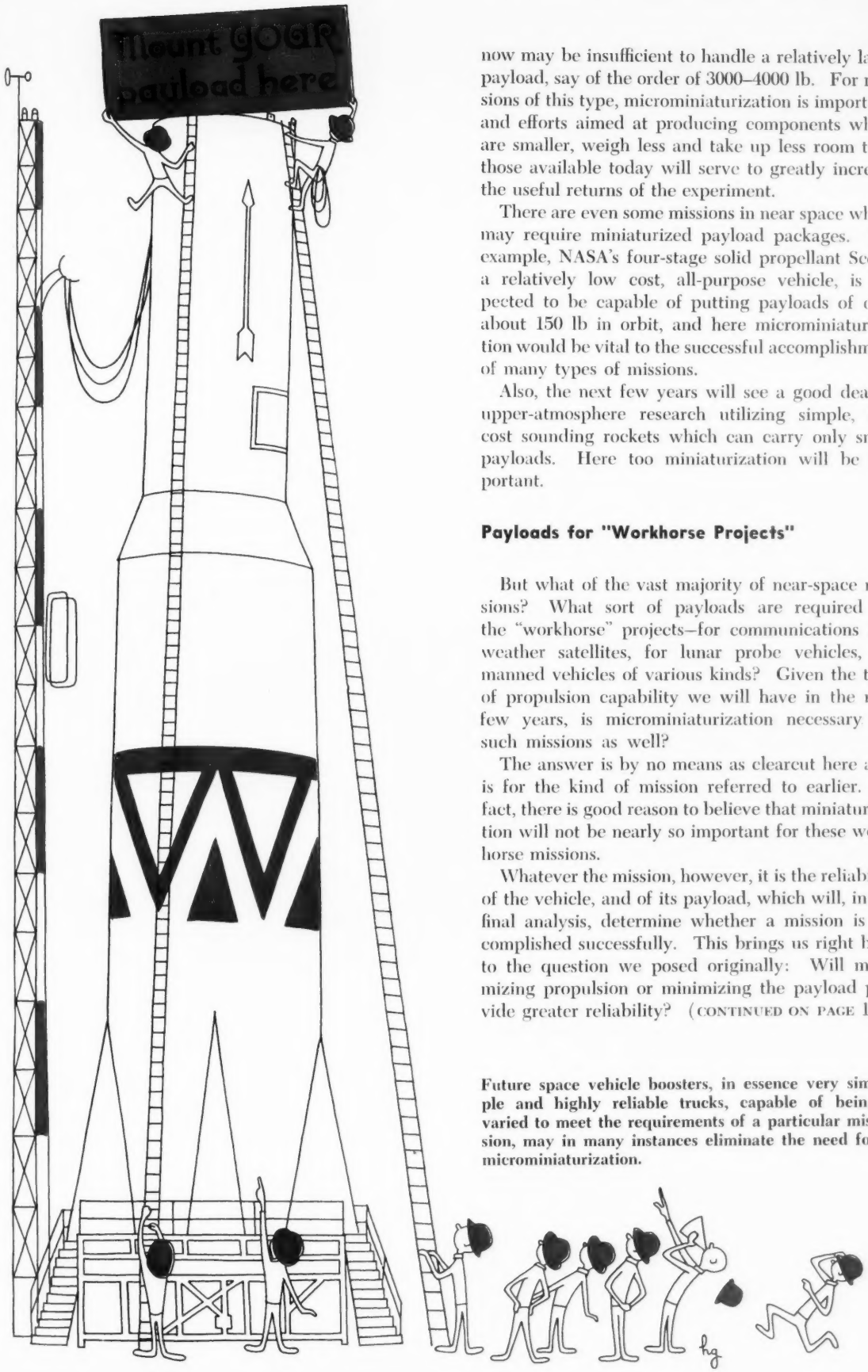
Also, the next few years will see a good deal of upper-atmosphere research utilizing simple, low cost sounding rockets which can carry only small payloads. Here too miniaturization will be important.

Payloads for "Workhorse Projects"

But what of the vast majority of near-space missions? What sort of payloads are required for the "workhorse" projects—for communications and weather satellites, for lunar probe vehicles, for manned vehicles of various kinds? Given the type of propulsion capability we will have in the next few years, is microminiaturization necessary for such missions as well?

The answer is by no means as clearcut here as it is for the kind of mission referred to earlier. In fact, there is good reason to believe that miniaturization will not be nearly so important for these workhorse missions.

Whatever the mission, however, it is the reliability of the vehicle, and of its payload, which will, in the final analysis, determine whether a mission is accomplished successfully. This brings us right back to the question we posed originally: Will maximizing propulsion or minimizing the payload provide greater reliability? (CONTINUED ON PAGE 116)



Future space vehicle boosters, in essence very simple and highly reliable trucks, capable of being varied to meet the requirements of a particular mission, may in many instances eliminate the need for microminiaturization.

Three Astronautical Pioneers — 2

K. E. Tsiolkovskii

an autobiography

Freely translated by A. N. Petroff

". . . In my life I have not only thought and computed, but, with my own hands, realized my ideas. But you cannot do without the idea. Thought goes before action, and imagination before exact computation."

—KONSTANTIN E. TSIOLKOVSKII

Background

More than half a century ago, an impecunious Russian schoolteacher, who never had anything remotely resembling a laboratory as we understand it, and who throughout his entire life struggled to raise the few rubles he needed to go on with his experiments, established the basic principles of space flight.

Inconceivable though it may be, by 1903—the same year as the Wright brothers' first flight—Konstantin Eduardovich Tsiolkovskii, his mind filled with haunting visions which he attempted to turn into reality, had completed a full-scale study of a manned space vehicle powered by lox-hydrogen rockets, and had conceived many of the ideas in use in today's long-range ballistic missiles and space vehicles.

Almost unknown at the time of his death in 1935, Tsiolkovskii (of whom Theodore von Kármán once said, "He was perhaps the first man to base a project for space travel on sound principles") and his monumental work have in recent years been the subject of innumerable books and essays.

Some months ago, A. N. Petroff, director of research, Research Engineering Dept., Cessna Aircraft Co., and president of the ARS Wichita Section, was kind enough to supply ASTRONAUTICS with a copy of this translation of Tsiolkovskii's autobiography, taken from "K. E. Tsiolkovskii, His Life Work and Rockets," by N. A. Rynin, published in Russia in 1931 and today extremely rare and almost unobtainable.

The brief but poignant document, presented here in English for the first time, presents a fascinating insight into the mind and life of the great Russian scientist in his own words.

This is the second in a series of autobiographical portraits of the three pioneers to whom present-day astronautical technology owes such a great debt. The Robert H. Goddard portrait appeared last month, while a new autobiography of Herman Oberth especially prepared for ASTRONAUTICS *will run in the near future.*

I WAS born on the 5th of September, 1857, in Ijevski Village of Riazan Provence, Russia. My parents were poor, my father an impractical inventor and philosopher. Mother, as father used to say, had a spark of hidden talent; among her relatives were many gifted people. I was eight or nine years old when she showed me a small toy balloon made of collodium and filled with hydrogen which aroused my interest.

At the age of 10, my hearing was impaired by the aftereffects of scarlet fever. Being almost deaf made me a victim of ridicule to the rest of the boys in the neighborhood. This handicap estranged me from people and prompted me to read, concentrate, and dream to keep from boredom. Hurt pride sought satisfaction. There was a desire to do something big, heroic, to be rewarded, and at 11 I tried to express myself by composing silly verses. At 14, I gained from a physics textbook some theoretical understanding of aerostatics, and tried to fill a sack made of tissue paper with hydrogen. The experiment failed.

At that time, I was also interested in mechanical flight by means of flapping wings. Among other things, I made a small model of a carriage which moved in all directions, with and against the wind generated by bellows. There was another model of a carriage powered by a steam turbine. Later, I decided to build a larger carriage for myself, suitable for travel, spending lunch money on lumber, screws, nails, etc. The project failed due to lack of patience and money and the final realization that the thing was impractical.

At 15 or 16 my knowledge of elementary mathematics gave me a better understanding of physics. Above all, I was interested in static balloons and already had enough data to solve the following problem: To find the dimension of a balloon, constructed of metal of a certain thickness, that would lift a given number of people. It was clear to me that the thickness of the skin will increase indefinitely as the balloon grows in size. Since then, the idea of a metallic aerostat stuck in my mind. It tired me out, and then for months I

was occupied with something else, but I invariably came back to it.

Systematically, I studied very little and read only what could help me solve problems that interested me at the moment. For instance, the theory of centrifugal force interested me since I thought it could be used as a means toward the end of flight in cosmic space. There was a moment when it appeared to me that I had solved this problem (at 16). I was so excited that I could not sleep the whole night, and instead spent it wandering through the streets of Moscow and thinking about the great consequences of my discovery. Toward morning, I was convinced of the fallacy of my invention. I still remember that night, and even now, 50 years later, I sometimes dream about rising in my machine toward the stars and feeling the same exaltation.

My tribute to perpetual motion, thank God, was small. The confusion lasted only several hours due to an incorrect understanding of magnetism.

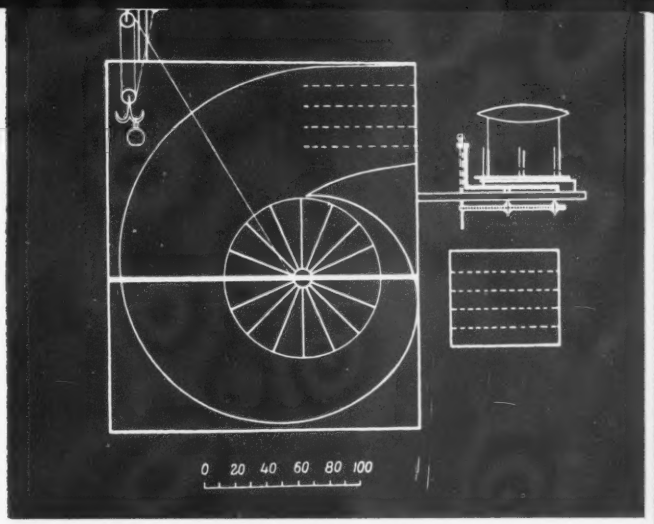
The thought of communicating with cosmic space never left me. It prompted me to study higher mathematics. Later, in 1895, I cautiously expressed my conjectures in "Dreams about Earth and Skies" and, still later (1898), in "Investigation of Cosmic Space by Reactive Machines," published in *Scientific Survey*, 1903.

Astronomy attracted me because I always thought that not only the earth, but the whole universe is the heritage of mankind. The articles "On the Moon," "Gravitation as a Source of Cosmic Energy," and others prove my constant interest in astronomy.

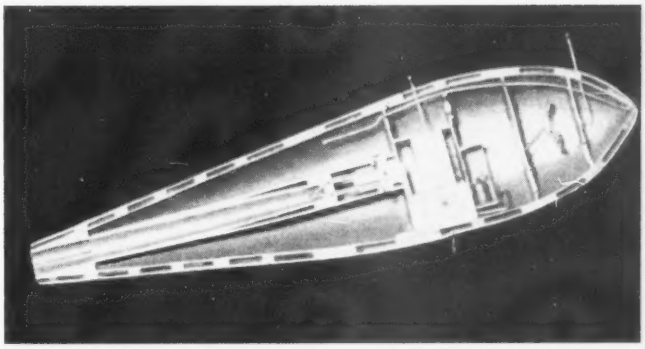
Books Were Nonexistent

Books on the subject of flight were practically nonexistent. Therefore it was necessary for me to think independently, and often, in the wrong direction. Quite often I invented and discovered things that were already known. I learned by creating, however—quite often without success and too late. For instance, in 1881 I worked out a theory of gases without knowing that it was 24 years too late. Nevertheless, by doing so, I acquired a habit of thinking independently and being critical of everything. It could be that self-reliance was in my nature. However, deafness and the compulsory withdrawal from society strengthened my initiative.

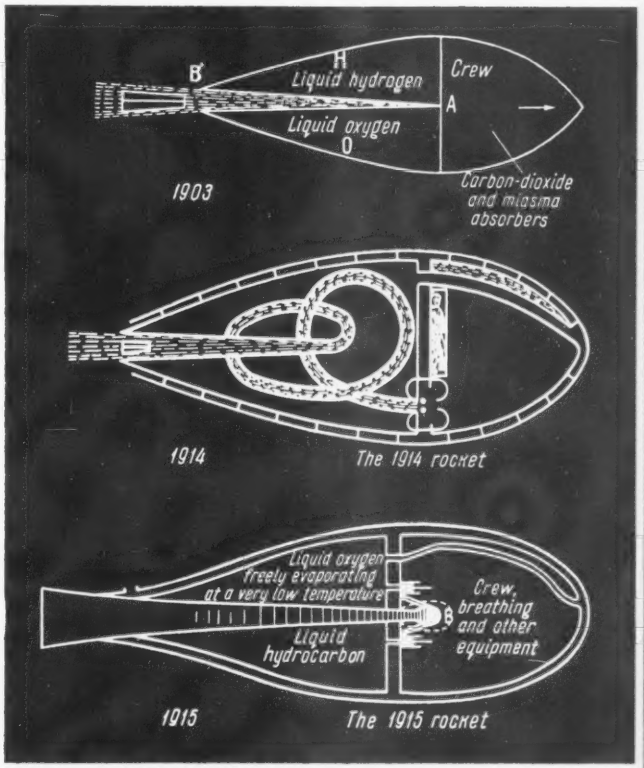
In spite of lack of formal education, I passed the required examinations and was granted a certificate for teaching in high school where I taught mathematics and physics for nearly 40 years. Although I read the textbooks, I found it easier to prove a theorem without the book since I was used to working independently. At 25, I was interested in the improvement of steam engines and made several models of blowers and (CONTINUED ON PAGE 63)



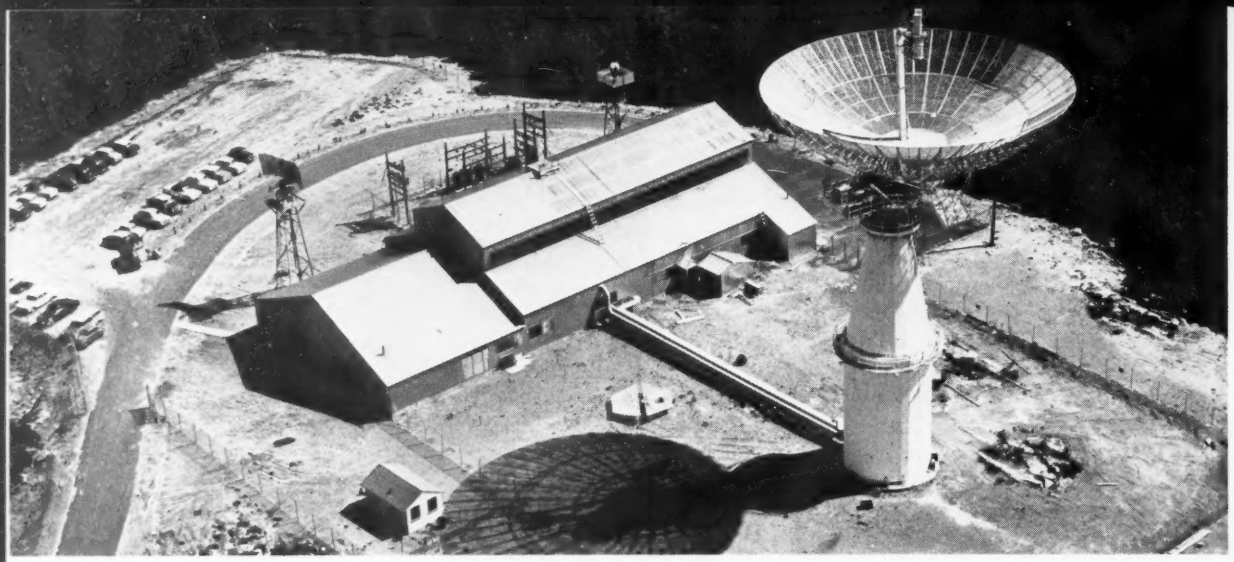
Tsiolkovskii's drawing of his wind tunnel.



Model of Tsiolkovskii's 1903 rocket.



Diagrams of Tsiolkovskii rockets.



Millstone Hill Radar Observatory at Westford, Mass., site of Venus experiment. Developed by MIT's Lincoln Lab for the Air Force to study problems of ballistic missile defense, the observatory features a very maneuverable 84-ft-diam parabolic antenna which contributes to what is not only a high power radar station but also the most precise and sensitive radio telescope presently operating in this country.

Radar contact with Venus

By itself a notable achievement in radar astronomy, first two-way contact with a planet also promises to refine the accuracy of the astronomical unit and help pave the way for coming interplanetary probes

By John A. Newbauer

WESTFORD, MASS.—After lunch on Feb. 10, 1958, a research group of MIT's Lincoln Lab beamed Lincoln's Millstone Hill research radar at Venus, some 28,000,000 miles distant, and transmitted a coded UHF (300–500 mc) radio signal with 265 kw pulse power for about 5 min, then switched to a receiving system incorporating a solid-state (chromium-doped potassium cobalticyanide) preamplifier and tape recorded reception for a like period. Two days later, they repeated the experiment.

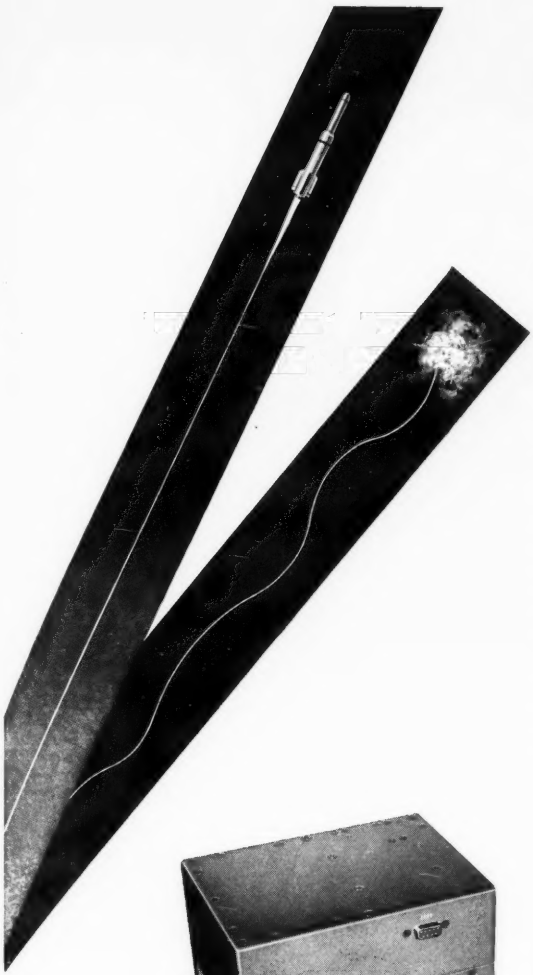
Over half a year later, after exhaustive computer analysis of the taped reception, they had an inkling that they had made history. A few months more and they could affirm the first two-way contact with a body beyond the moon, with these results:

Date	Feb. 10, 1958	Feb. 12, 1958
Time	14:21:05 EST	12:00:55 EST
Signal travel, sec	295.5075	302.9842
Estimated accuracy, sec	±0.0005	±0.0005

Besides its historical savor, this experiment provides the first direct measurement of an interplanetary distance. The signal time-of-travel measurements reduce, on first estimate, to an uncertainty in Earth-Venus range of 100 miles, based on certain assumptions concerning radar-propagation speed in space and in the planetary atmospheres, and on experimental conditions, which are still under study.

Refinement of Astronomical Unit

An unambiguous interpretation of Earth-Venus range from the experiment can lead to the first notable refinement of the astronomical unit (mean radius of the earth's orbit about the sun), which is the standard reference for the very precise determinations that have been made of *relative* interplanetary distances. The present value of the astronomical unit intro- (CONTINUED ON PAGE 124)



COMMAND DESTRUCT

The flight testing of second generation missiles—more versatile and powerful than their predecessors—requires a device for sure termination of any missile flight that might endanger the test range or surrounding area.

Ramo-Wooldridge engineers, under a United States Army Signal Corps contract, have successfully developed and delivered the first sub-miniature, completely transistorized radio "command destruct" receivers.

Specifically designed for missile flight safety operations, the receiver (AN/DRW-11) can actuate safety mechanisms or destruct devices. It has three command channels, each of which actuates a control relay.

The "command destruct" receiver accepts frequency modulated signals in the UHF radio command control band. It is designed to operate with closer radio frequency and command frequency channel spacing than has been used to date, thus making possible more efficient use of the available radio spectrum.

Compact and rugged, the radio receiver's modular construction permits rapid and complete accessibility to all components. One module houses the basic receiver. The second module contains the three command channels and relays. This integrated package occupies 115 cubic inches, and weighs 4 pounds. The receiver requires no pressurization and operates reliably under the adverse environmental conditions encountered in missile flight testing.

Engineers and scientists interested in being associated with some of the nation's most advanced research and development programs are invited to acquaint themselves with current opportunities at Ramo-Wooldridge. The areas of activity listed below are those in which R-W is now engaged and in which openings exist.

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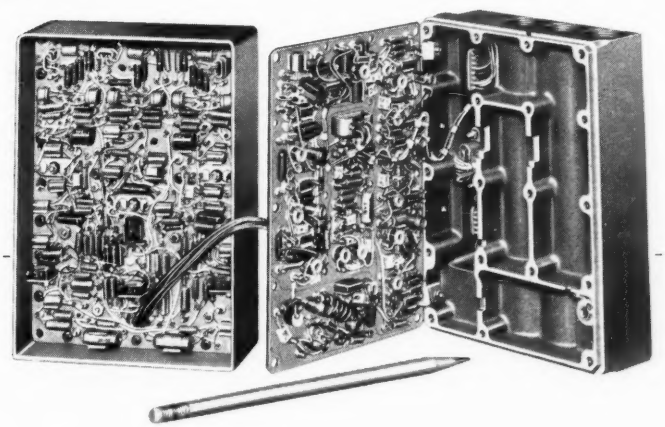

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Missile market

BY JEROME M. PUSTILNIK, Financial Editor

MISSILE stocks continue to push upwards. In the over-the-counter markets especially some of the smaller electronics companies that are doing work on missile and defense systems have had some spectacular (and speculative) gains.

Against this background, however, two recent and widely separated events provide some food for thought. These may have some basically unfavorable effects on numerous companies in these fields.

The word "basically" is the key here. We are not overly concerned with such temporary influences as the financial fashionableness of the industry's shares, nor their stirring daily price action, even though the latter distracts investors from long range programs. Should there be a shift in this attention, it would not alter fundamental investment characteristics.

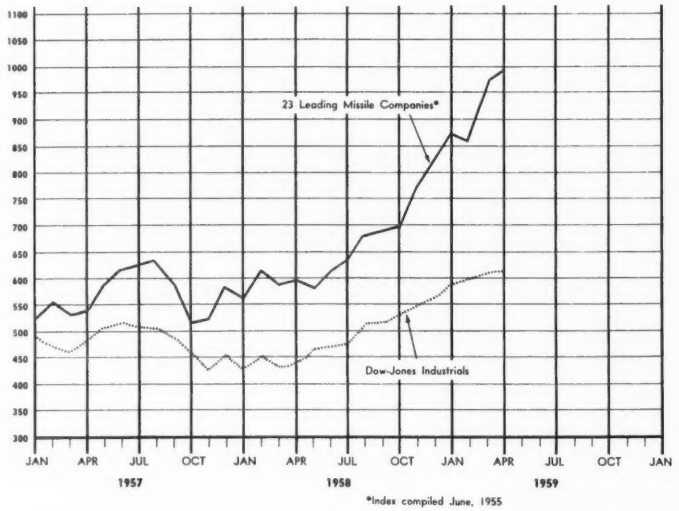
But the ingredients of really fundamental changes may lie in what any observer could see at the recent IRE show, and in the results of Project Argus. Both events may be harbingers of things to come. While the reasoning which follows may not be popular these days, successful long-term investing has never been based on easy acceptance of popular thinking.

At the IRE show, one could not help but be impressed by the large increase in the number of manufacturers in the field and in the products on display. Power supplies, relays, digital computer readout equipment, and a variety of semiconductor devices are just a few examples. Quite a few of these manufacturers are small firms, or at best only modest in size. As competition for sales grows, the investment significance of this situation emerges.

History may not always repeat itself, but investors cannot ignore, except at their own peril, the frightening mortality rate among manufacturers in the radio industry and, 20 years later, those in television.

Missile industry expenditures *are* zooming. It would not be prudent, however, to expect this growth to absorb the output of all producers in large enough quantities so that all could operate profitably. Invoking history as a guide, a wave of mergers and consolidations will engulf many of the smaller companies as they are swept up by their larger competitors. Too many, unfortunately, will find their only refuge in the provisions of the Federal Bankruptcy Act.

THE MARKET AT A GLANCE



*Index compiled June, 1955

	April 1959	March 1959	% Change	April 1958	% Change
Dow-Jones Industrials	602	603	—	449	+34.1
Missile Index	997	972	+2.6	596	+67.3

Project Argus also portends basic changes in the industry. Controversy, initially over whether to make the news of the tests public, still surrounds Project Argus—this time over interpretation of the test results. What has been published, however, seems to indicate that we may have to revise completely our thinking about the effectiveness of some of our current programs for anti-missile missiles, countermeasures, missile warning systems, and communications.

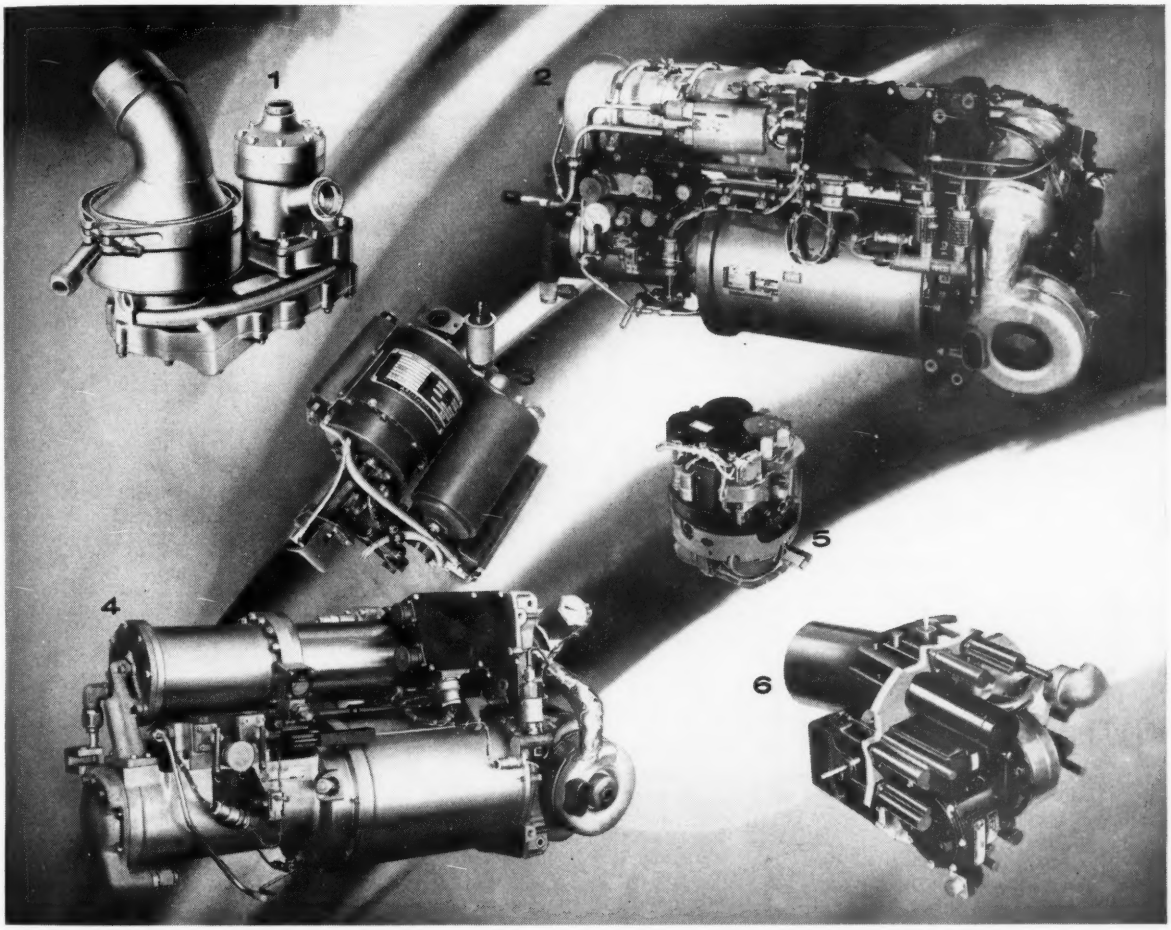
Neither factor implies that missile industry investors should sell their shares indiscriminately, for even in adversity there will also be opportunity. Large profits *will* be earned by many companies in the industry, and their stockholders will be rewarded commensurately. But it is imperative that these investments be chosen with great selectivity and reviewed often. It is easy to be swept up by the current speculative fever, and to invest in *markets* instead of *companies*. If one does, paper profits may evaporate as quickly as they appeared. Long term investments in *sound* companies should still be the objective. Here, then, are some basic criteria to apply before leaping into new commitments.

Management, the most difficult factor to evaluate, is the most important. Most missile companies are highly specialized, yet nowhere else is technological change so swift. An added burden is thereby placed upon management, which must be alert to, and often anticipate, these changes. Management should endeavor to develop proprietary products and innovate, not imitate. Management should seek out promising areas of activity while avoiding those which are intensely competitive. Good business sense should be combined with scientific ability, and high profit margins should be maintained with increasing volume.

Adequate finances are another must. There is no substitute for money in the bank when selling and promotional expenses soar and competition waxes hotter. Liquid finances will also pay

(CONTINUED ON PAGE 112)

DELIVERED—thousands of missile APUs



1. *Solid propellant—hydraulic output* **2.** *Liquid propellant—hydraulic and electric output* **3.** *Solid propellant—electric and mechanical drive output* **4.** *Liquid propellant—hydraulic and electric output* **5.** *Solid propellant—hydraulic and electric output* **6.** *Solid propellant—hydraulic, electric and steering outputs*

AiResearch has designed, developed, manufactured and delivered thousands of missile accessory power units. Extremely reliable and lightweight, these various solid and liquid monopropellant APUs are completely self-sustaining within the missile system. Designed to minimum space and weight requirements, they are built to withstand high G loading and severe temperature extremes.

The several units pictured above provide hydraulic, electrical and/or steering surface control depending on the customer's requirement. Delivered horsepower ranges from 1.2 to 35 h.p. over hot gas operating durations from 30 seconds to 20 minutes. Electrical regulation is maintained as closely as ±½%. A significant advance in missile APUs is unit #6 pictured above. This package represents the first integrated hydraulic and electrical power unit providing a steering surface actuation system.

These tailored systems utilize the extensive hardware experience and complete laboratory, test and production facilities of AiResearch needed for quick and efficient quantity production of complex APU systems. AiResearch is the world's largest and most experienced manufacturer of lightweight turbomachinery — the key component of its APU systems. Your inquiries are invited.

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Miniaturized Computers

(CONTINUED FROM PAGE 43)

magnetic drum; and binary machine language (word length, 26 bits) utilizing a two-address code and a redundancy bit for increased accuracy of incremental additions. The arithmetic element is serial. Its repetition rate is 166 kc. Instruction storage handles 2650 words; data storage handles 960 words.

Addressable registers under direct operator control are employed to indicate the storage location of numbers to be inserted or displayed and the appropriate scale factor to be applied. A mode register instruments a logical choice philosophy of machine operation at the operator's discretion. The console associated with Dinaboc has been designed using human engineering concepts.

Display, insert, and printout operations are performed in the decimal code. Any one of 41 quantities may be inserted or displayed to an accuracy of six decimal digits for monitoring or making corrections. Ten data words of six decimal digits plus sign can be programmed internally or operator selected with three choices of printout cycle for monitoring and log keeping. Translation from binary to decimal and decimal to binary is performed automatically through a wired program routine in the arithmetic unit. Although Dinaboc was designed for a specific application, it may be utilized for a variety of real-time control applications.

Unique Methods Used

The problems involved in reducing advanced computer techniques to a workable and practical airborne control system have required some unique applications of digital technology, especially in the areas of packaging, logical organization, and miniaturization.

One of the more difficult problems in placing a digital computer into an aircraft has been in the area of the computer memory system. The control problem for an advanced weapon system requires a comparatively large capacity storage device physically much smaller and lighter than an equivalent commercial device and able to withstand severe environmental changes. These requirements have been fulfilled in Dinaboc by the magnetic drum shown on page 43. This drum operates in a temperature range from −20 to 75 C and under vibration conditions up to 55 cps at 10 g. The final drum design provides a storage capacity of 100,000 bits of information and weighs only 12 lb. Most commercial drums have the same capacity weight at least 10 times as much and must be operated in a controlled environment.

To accomplish this design, special materials and techniques were used throughout. The drum, framework, and housing are made of magnesium to gain minimum weight. A nickel-cobalt alloy is used for the drum plating to provide a suitable magnetic recording surface. The drum motor is housed within the drum cylinder to conserve space.

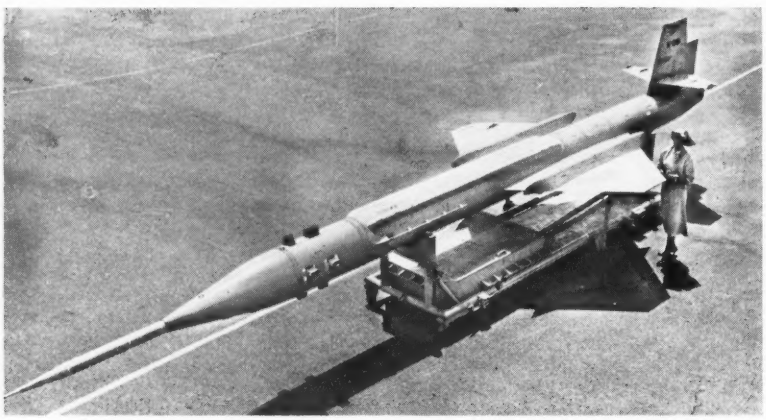
The most unusual design feature is in the read–write heads. Because of the rapidly changing temperatures found in an aircraft and the tendency of a low mass drum to bow at high speeds (6000 rpm), special consideration had to be given to the problem of maintaining a proper drum-to-head clearance. If this clearance is not maintained to 0.0001 in., an adequate readback signal cannot be obtained.

Solution

This problem was overcome by designing a floated head which automatically adjusts to the changing contour of the drum. This air-floated head is shown on page 43. The design takes advantage of the phenomenon that when a cylinder is rotated rapidly it creates a thin laminar air film around its periphery. This air film is sufficiently dense to support a lightweight magnetic head. The head, however, must be equipped with a shoe-like device, which presents enough surface area to the air boundary for proper floating. The geometry of the shoe determines the drum-to-head clearance. This technique has allowed increasing drum eccentricity from 25 microinches, as used with conventional heads, to 1000 microinches without degrading the recorded signals. Also, critical head adjustments normally associated with drum assemblies have been eliminated. Another advantage of this air film supporting technique is that it permits an increased recording density because of the reduction in head-to-drum spacing.

The designers of all magnetic drum computer systems have had to contend with the latency problem associated with extracting data from storage. Magnetic head locations, operation execution times, data and instruction word storage locations, etc., have all been tailored to derive minimum latency programming of each particular control system. A random access memory has obvious advantages in eliminating this problem. One contemporary computer uses a magnetic-core random access memory for both

New and Hotter Version of X-7



This beefed-up version of the recoverable X-7, built by Marquardt Aircraft for Lockheed, will flight-test the newest high-powered ramjets for advanced AF interceptor missiles.

Sleeker than any of its forerunners, this 37-ft long version of the X-7 has a number of advanced features, including (1) ability to carry four different types of ramjet engines; (2) autopilot which responds to commands in $^1/_{16}$th of a second, twice as fast as the older version; (3) camera instrumentation that permits twice as much film coverage during the entire flight; and (4) underwing boosters to allow ground, as well as air, launches. The X-7 will be launched from the bomb-bay of a modified B-50 at the AF Missile Development Center, Alamogordo, N.M., and guided from the ground.

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data and instruction word storage. Other control systems utilizing magnetic cores for dynamic data storage and magnetic drums for program storage are in advanced stages of development. The ever increasing demands for greater speed and capacity in airborne control systems make such a combination of storage devices attractive.

The weight and size restrictions imposed by an airborne application have necessitated the use of semiconductors rather than vacuum tubes for all Dinaboc circuitry. Germanium junction transistors and point contact diodes are used throughout. The diodes are used as the logical elements and the transistors for switching, read–write and power circuits. Relatively high speed circuits are obtained using conventional techniques, such as saturation limiting, clamp diodes, and complementary symmetry. The majority of circuits are direct coupled and use negative logic. Temperature compensation makes operation possible over a range from −20 to 55 C. An operating bit frequency of 166 kilopulses/sec is utilized in conjunction with four clock phases. The logic networks are gated by timing pulses supplied through diodes.

Most sensor devices in modern guidance systems produce analog information, which in itself is not compatible with digital computation. Therefore, conversion equipment is necessary to translate this information into machine language. The two types of converters used in Dinaboc for this purpose can be described as shaft-to-digital converters and pulse-to-digital converters.

The shaft-to-digital converter consists of a coded disc coupled to the shaft of the analog device, e.g., motor, potentiometer, resolver, etc. By sensing the disk with brushes, the analog shift position can be numerically defined to the desired resolution. This number is proportional to the angular position of the shaft and is in the proper digital code for computer use. Until recently, the size and inherent ambiguity of this type of converter have prohibited its use in airborne systems. However, by a unique modular packaging technique, which can be seen in the photo on page 43, and the use of nonambiguous codes, this type of converter is now practical.

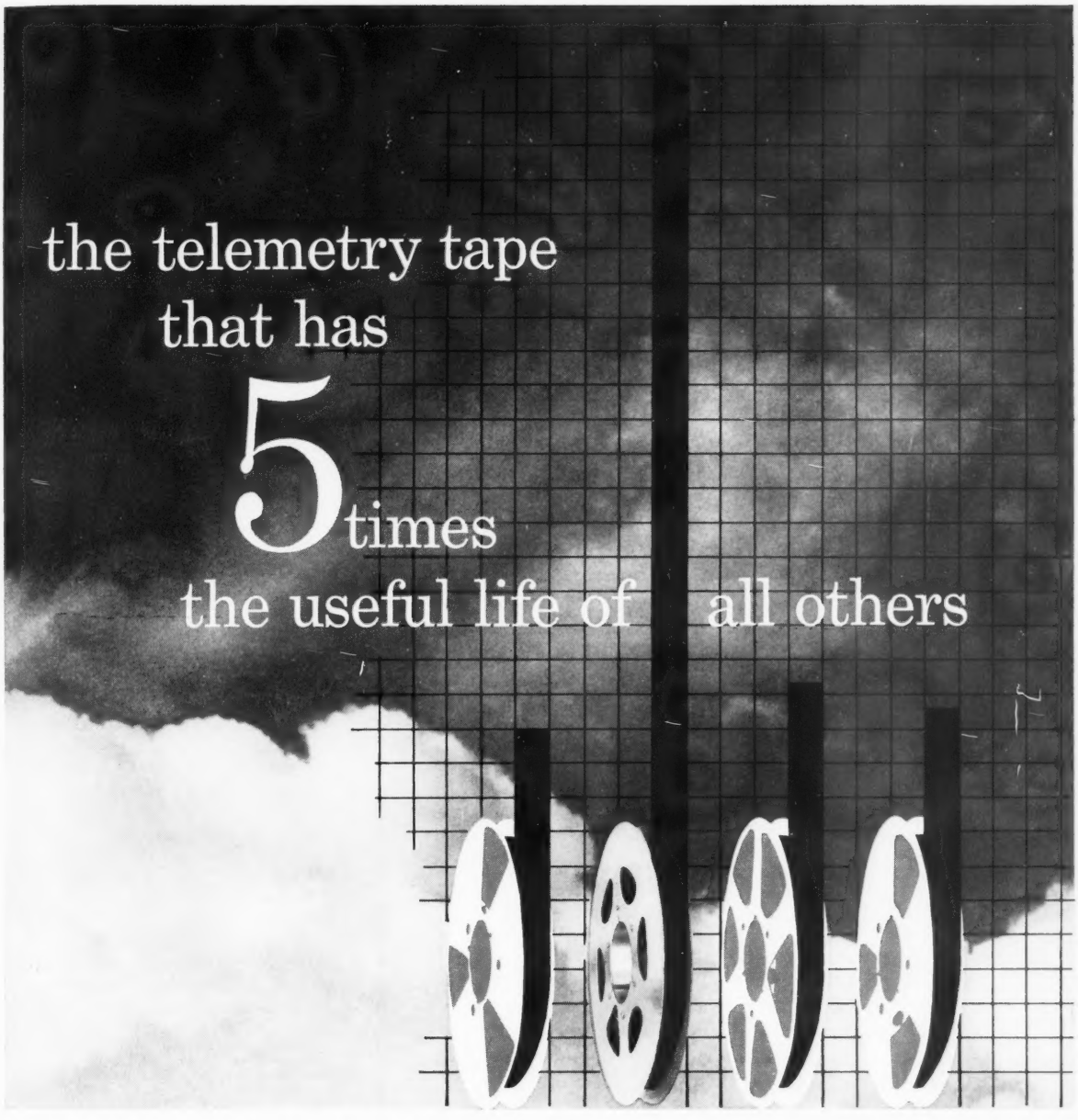
The pulse-to-digital converter is a simple counting device which accumulates a train of pulses for a given length of time in temporary storage registers. At the end of the time, the contents of the storage registers are gated into the computer as a binary number. Triggers, latches, delay lines or cores are used as the temporary storage medium.

After the computer has determined what the value of a particular control parameter should be, this value is then compared with the actual or input value of the parameter and the difference exists as an error in digital form. This error must be converted to an analog quantity to effect correction to the peripheral control devices which are normally analog in nature. This conversion is accomplished in Dinaboc by a magnetic core processor consisting of a core register coupled to a 400-c reference voltage. The cores are controlled by DC saturation signals representing digits in the binary error number to be converted. Each core produces a 400-c signal addition to the output voltage if the corresponding information bit is present. According to the combination of cores energized, a final output voltage is produced which is proportional to the error.

Human Operator

Although many advanced airborne control systems provide a completely automatic guidance capability, manned vehicles still require a human operator in the control loop. This requirement places considerable restrictions on the digital computer, for it must now operate compatibly with the comparatively slow responses of a human as well as the high speed responses necessary for airframe control. To provide this capability in Dinaboc, an integrated console has been designed which intimately relates the operator with the control problem. By proper selection of controls, the operator can initiate alternate modes of operation, insert new information into the computer, or cause any one of a number of significant parameters to appear in decimal form on a common display panel. Also included as part of the console is an inflight printer which continually records computer results during the course of the mission. Dinaboc and its console also can correlate a manual tracking task with a radar display. In performing this task, the operator endeavors to superimpose a crosshair on a moving target. The position of the hand control is periodically sampled by the computer, which then calculates the crosshair position and displays it to the operator.

Reliability is a key word in the design of present-day airborne control systems. To assure the greatest prob-



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ability of successfully completing a mission, several novel design approaches have been used in Dinaboc. Component de-rating is one technique which has been used to provide greater reliability. Conservative circuit design to prevent ordinary component degradation from causing circuit failure is another method for improving reliability. Other techniques which increase the probability of mission success include diagnostic check routines for quickly isolating faults, marginal testing for eliminating questionable components, alternate mode capability, parity checking, and redundancy in the basic organization (two synchronized computers operating in parallel).

Dinaboc Contribution

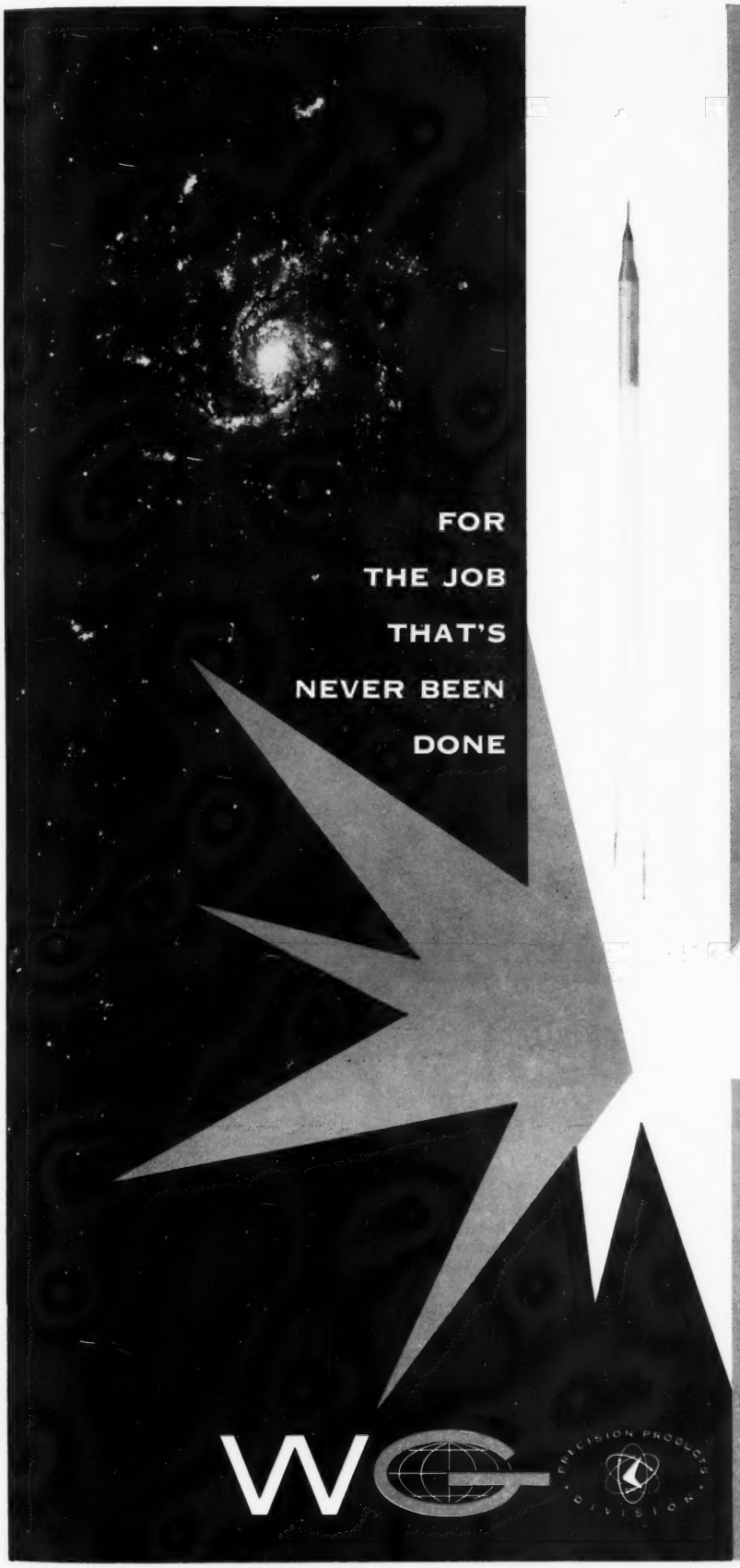
The Dinaboc basic technology has contributed toward a more advanced computer that is currently being developed by IBM for the B-70 weapon system. This computer carries 13,000 instructions stored on a magnetic drum. Over 3000 constants, such as ballistic data and star tables, are also stored on the drum. To obtain even faster computing speeds, a random access data memory of 1024 words, composed of stacked ferrite apertured plates, is also included. The photo on page 43 shows one of the ferrite plates.

High speed computing is provided through parallel operation of the arithmetic unit. Conventional binary numbers, with a fixed point, are used. Each data word in the computer is comprised of 22 binary bits, plus a sign bit and a check bit. Simplified programming is possible because of the single address characteristic, in which the result of one operation becomes one of the two operands for the succeeding operation.

Theory and technology will continue these advances in the design of compact, versatile computers.

In the field of components, the multihole ferromagnetic structure holds great promise. A knowledge of the transient and steady state flux patterns within these structures has led to the synthesis of practical computer logical connectives. These devices provide computer designers with small, versatile, and rugged logical building blocks tailored to the demands of the advanced guidance computer. Furthermore, these ferromagnetic structures are immune to the effects of radiation.

The cryotron is another important component available for advanced digital systems. Cryotrons used to operate at speeds slightly greater than electromechanical relays. Today



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Patrick Air Force Base, Fla.

PAN AM
GUIDED MISSILES RANGE DIVISION
PATRICK AIR FORCE BASE, FLORIDA

cryogenics technology has progressed to the point that cryotrons are now available which switch in less than one millimicrosecond. The extreme miniaturization and very high reliability available through the use of cryotrons make them particularly attractive components for advanced airborne digital systems. A concomitant disadvantage associated with cryogenic applications is extremely low temperature. However, work has progressed well in the development of a closed-cycle cryostat of reasonable size.

In the area of memory systems, important advances can also be envisaged. The cryotron itself is an important device for memory applications. The logical extensions of magnetic core and aperture plate memories—thin films and twistors—will receive considerable attention in the search for storage devices having higher capacities, smaller power requirements, faster access times, and less space. Remarkable improvements in magnetic drum technology keep drums in the competition for future memory systems. Not far away are drum memories of 500,000 bits in a volume of 0.05 cu ft and a weight of 3 to 4 lb, with a maximum access time of 1 millisec. The designer of the future airborne digital computer will probably combine the advantages of two or more memory types into an optimum system.

Further improvements in computation capacity can be achieved by the use of an improved concept of machine logical organization. In particular, some of the newer airborne computers combine the advantages of incremental computation and full-value (GP) computation in a single hybrid system. Continuing research in this area will undoubtedly provide more effective hybrid systems.

Improving Reliability

The most serious problem confronting the designer of future airborne computers is reliability. The long mission times and severe environments that can be anticipated in some future systems combine to establish mean-time-to-failure requirements from one to three orders of magnitude longer than available with present equipment. The actual reliability improvement required depends largely on whether inflight maintenance is feasible. The use of well-known techniques to achieve improved reliability —such as those mentioned in connection with the Dinaboc program—will not be sufficient to achieve the amount of improvement required. This is not to say that such techniques as component de-rating, careful component testing and selection, conservative circuit design, etc., should be abandoned. But these techniques must be supplemented with a reliability program based on redundancy. Information theory establishes the fact that reliability can be improved to any desired degree by the use of redundancy, and some practical applications of these principles have been suggested by von Neumann, Shannon, and others. Theoretical work is continuing in this area to discover new redundant computer configurations.

"Triple Modular Redundancy"

A current technique called "triple modular redundancy" offers excellent potential. This technique exploits the principle that redundancy is most effective when applied at the lowest feasible level in the system. The method essentially requires breaking the computer into modules, triplicating each module, connecting the outputs of the three modules into a von Neumann "majority organ" (voting circuit) to form a "trio," and reconnecting the trios as the original modules were connected to form the triple modular redundant computer.

The diagram on page 43 shows that in practice the voting circuits are also triplicated, so that the failure of one voting circuit will not fail the computer. One can show that triple modular redundancy effects a greater improvement in reliability with greater reliability of the individual modules. Thus the technique should be thought of as a means of greatly amplifying the reliability improvement achieved by the more conventional techniques. Although the method clearly requires more than three times the equipment required in the original computer, the effect of this increase is balanced by future trends toward even smaller components and improved packaging. The technique of triple modular redundancy has never been adequately tested in a physical system, but simulation studies indicate that substantial reliability improvements can indeed be achieved.

The computer industry has managed to exceed the computational requirements arising from aeronautical achievements by applying well-established digital techniques to the airborne control problem. Future guidance problems indicate that new approaches, completely divorced from contemporary commercial data processing techniques, must be applied to advanced control systems. The Dinaboc's of today are giving direction to these approaches, many of which have already been formulated on the drawing board and soon will be guiding spacecraft.

YEAR II
...of the SPACE AGE

Future historians will refer to 1959 as Year II of the Space Age. In the Year I we have proven the feasibility of space vehicles. What will Year II bring? In our telescoped sense of time . . . the analogy to Columbus' second voyage . . . and the opening of the New World, is inevitable.

Electronic systems for space vehicles that are still on the drawing board is the goal of Airborne's Project STAR (Space Technology and Advanced Research). The staggering problem that faces electronics researchers is how to design space-borne equipment that will operate reliably without human attention over indefinite periods of time, under conditions of an environment uniquely hostile to present engineering techniques.

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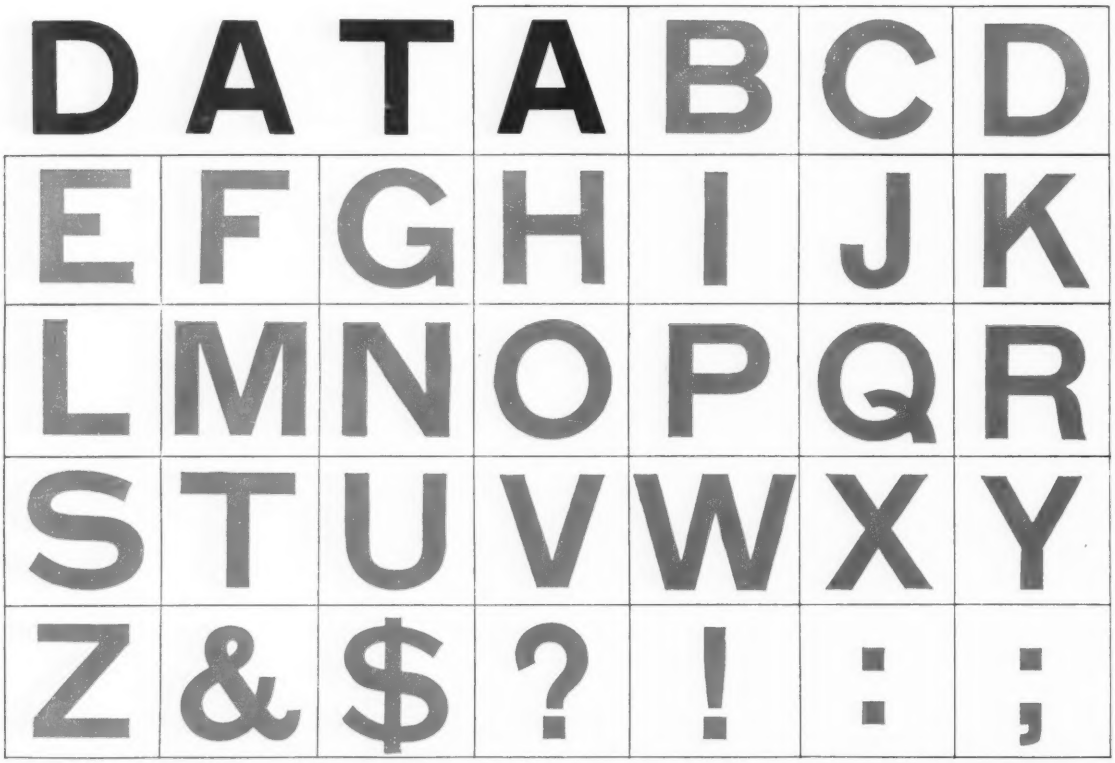

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Qualifications: B.S., M.S., or Ph.D. in Electrical or Mechanical Engineering, Physics, or Mathematics — and proven ability to assume a high degree of technical responsibility in your sphere of interest.

GENERAL DESCRIPTIONS OF SOME ASSIGNMENTS:

SYSTEMS ENGINEERS to analyze and design computer systems. Backgrounds required include analog to digital conversion; analyses and preparation of diagnostic programs; development of complex devices in servo-mechanisms or radar for advanced systems.

LOGICAL DESIGNERS with two to four years' experience outlining logical blocks. Previous computer experience desirable. Some experience in transistorized equipment specification helpful. Must have strong interest in the theoretical and practical aspects of checking means and various codes, redundancy, error detection and correction, information flow, and other factors.

SOLID STATE ENGINEERS AND SCIENTISTS to do applied research on precision linear circuitry employing solid state devices using analog to digital conversion techniques and sample data. Experience in feed-back amplifier design desirable. Also opening for engineers with experience in precision, low-level linear circuits employing solid state, to work on analog to digital conversion techniques.

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INDUSTRIAL CONTROL ENGINEERS to perform precision AC and DC electric measurements. Assignments in amplifier design, relay circuit logic, test equipment development, analog to digital conversion, and noise reduction.

CIRCUIT DESIGNERS to design transistor amplifiers, relay lines, transistor tube conversion circuits. Develop systems circuit specifications, perform circuit evaluation experiments and reliability criteria. Other openings in circuit design for magnetic devices.

MATHEMATICIANS to do digital computer programming, handle analysis-of-variance and multiple-regression type problems. Design experiments for wide variation of engineering applications. Knowledge of application of probability or game theory desirable.

Tsiolkovskii Autobiography

(CONTINUED FROM PAGE 49)

pumps in order to acquire experience in shop work.

Finally in 1885, at 28, I dropped this hardware and firmly decided to devote my efforts to aeronautics and the theoretical development of a dirigible, a project I worked on for two years. I was a conscientious teacher and came home from school very tired. Only toward evening could I resume my calculations and experiments. What to do? There was not enough time and energy for both. I tried getting up at daybreak, working on my project and then going to school to teach. After a second two-year period of mental strain, there was a constant heavy feeling in my head. Nevertheless, in the spring of 1887, I made the first public presentation on metal dirigibles at the Society of Natural Sciences in Moscow. Reception was sufficiently encouraging. The manuscript "The Theory of Dirigibles," consisting of 480 pages and 800 formulas, was given to Prof. Joukovski for comments. I did not think that his work was sufficiently complete, but asked, for the good of the project to be transferred to Moscow. This was promised, but for some reason the transfer was not approved.

Then I became ill, temporarily lost my voice, and fire destroyed my little library, shop, and models. In a year, I recovered and resumed my work. In the autumn of 1890, through Prof. Mendeleev, I sent to the Imperial Russian Technical Society my new work: "On the Possibility of Construction of a Metal Dirigible," along with a model. Shortly, through the newspapers, I learned that the Society had found my calculations and ideas to be completely correct. Later, I received a copy of the comments, which encouraged me considerably.

Investigation of flight on wings showed me that this method required a greater amount of energy than was anticipated from incomplete experiments, a fact which subsequently was corroborated in practice. This conclusion again caused me to lean toward dirigibles. Another effort resulted in a new work, "Maneuverable Metal Dirigibles." My brother and friends helped to publish it in 1892. I was never so happy as I was looking over the printer's proofs of this work. In 1894, I paid my last tribute to the airplane by publishing in *Science and Life* a theoretical investigation showing the advantages of gas-filled metal dirigibles.

The controversy between the dirigible and the airplane pushed me to

make experimental studies of air resistance. Theoreticians found the air resistance of dirigibles to be enormous. My experiments showed that it was not so significant and that the drag coefficient reduces with speed. Experiments were conducted inside and sometimes on the roof of the house in a strong wind. I remember how excited I was to find that, when a strong wind was blowing, the coefficient of drag was found to be smaller. I nearly rolled off the roof and hit the ground without feeling it.

Little Funds

Sympathetic reviews by the press brought several donations to help the cause of aeronautics. Altogether, I received 55 rubles which were used for new experiments on air resistance. I received the money with much gnashing of teeth since several donors, through a misunderstanding, were giving for the sake of charity. I suffered greatly, but endured, hoping for the possibility of carrying out future work. In spite of considerable publicity, the total amount was negligible. For instance the city of St. Petersburg sent 4 rubles toward the cause of aeronautics. Results of the experiments and a description of the setup were published in *Messenger of Experimental Physics* in 1899 in an article entitled "Air Pressure Upon a Surface in an Artificial Flow of Air." This work, submitted to the Imperial Academy of Science, was received favorably and brought 470 rubles toward continuation of the experiments.

These experiments, along with calculations, gradually clarified my understanding of the true nature of air resistance. The accuracy increased with each succeeding step, but it was still a far cry from the absolute truth.

I wanted to continue this journey along the path of science. But how could I gather enough energy, means, and support? In these experiments, I arrived at many new conclusions toward which scientists felt rather skeptical. These conclusions can be corroborated by succeeding experimenters. But where are they?

It is difficult to work alone for many years, under unfavorable conditions, without encouragement and support. It is true that sometimes, on rare occasions, there were expressions of sympathy and understanding. For instance, a group of students at Kaluga Technical College found my concept of a metal dirigible entirely practical.

In the 1920's, I resigned from my teaching post due to poor health. I always liked to teach even though it took almost all my strength, leaving very little for my own studies and work. I wrote, calculated, and worked with my hands mostly during holidays and vacations.

Space Flight Theories

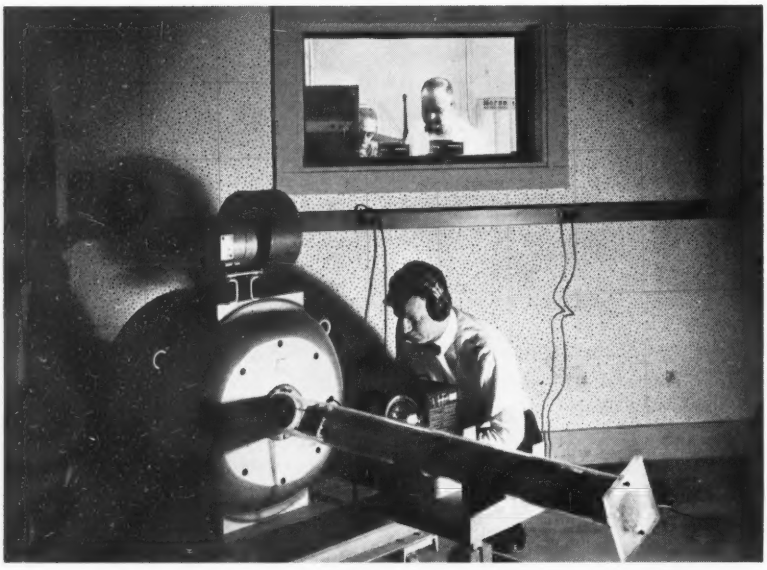
In the course of my work, I developed theories concerning certain phases of flight into space by means of a reactive device similar to a rocket. Mathematical deductions, based on available data already verified, indicated the possibility of human ascent into space, perhaps to populate areas beyond the earth's atmosphere. Perhaps, a hundred years will pass before my idea will find application and people will travel not only upon the surface of our globe but also upon the face of the universe. Almost all the energy of the sun is uselessly wasted as far as humanity is concerned, earth receiving only two-billionths of what the sun emits.

What is so strange about the idea of utilizing this energy? What is so strange in the thought of penetrating the endless space surrounding our earth? At any rate, is it a sin to express such ideas, since they are the fruit of serious labor?

Since childhood, partial deafness resulted in a total ignorance of the ways of everyday life, and therefore a lack of "connections." Perhaps, this is the reason that even at 68 I did not progress and had no real success. All my life consisted of meditation, calculations, and experimental work. The shop in the basement of my home always followed me. When destroyed by fire or flood, it was shortly restored.

It is boring to talk about myself and the small events of life while there are so many unsolved problems, unfinished or unpublished papers. The main things are still ahead. Will there be enough strength and ability to transform these thoughts into reality?

Noise Tests Missile Components



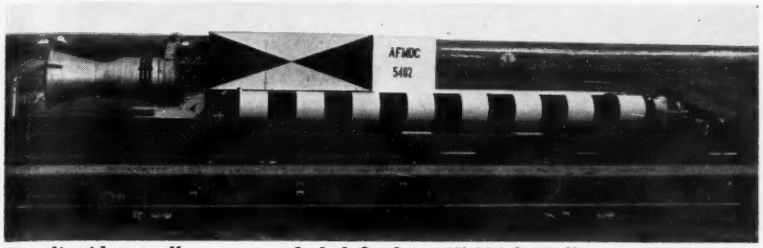
Avco acoustic noise generator subjects a nose cone component to as much as 170 db in progressive wave tube.

Missile components that pass mechanical vibration tests can still fail in high random-amplitude noise produced by the rocket engine and by re-entry. As laboratory testing with an actual rocket engine to determine the resistance of a component to noise is neither practical nor economical, it has become the practice to build powerful loudspeakers to generate high levels of random noise for such testing.

Avco Research and Development Div. has designed, for example, the acoustic noise generator shown here for testing critical components for Titan and Minuteman re-entry bodies. An electromechanical unit with a 12-in. moving coil, the generator produces noise of random amplitude at discrete frequencies up to 170 db. Components are tested in a progressive wave tube, operating systems in a reverberant chamber.

Avco has tested an operating system of relays, transducers, oscillators, transmitters, power supplies for Titan re-entry body with this generator.

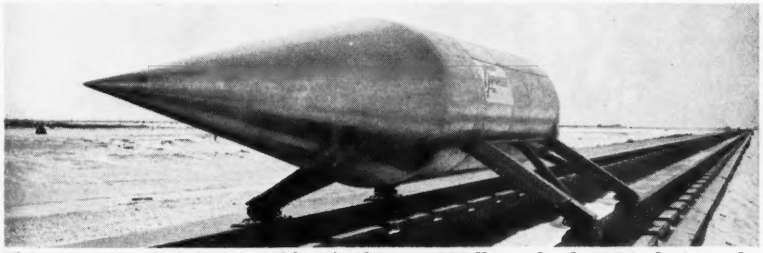
35,000-ft Holloman Test Track Opened



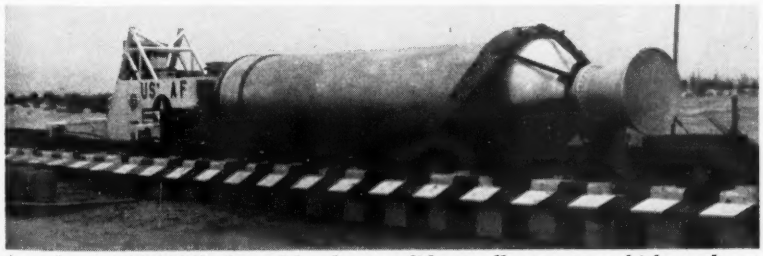
First liquid propellant powered sled fired on 35,000-ft Holloman AFB captive missile test track, officially opened Feb. 25. Lox-alcohol engine produces 50,000 lb of thrust for 4.5 sec.

This two-stage monorail sled reaches peak speed of 2700 mph on the track, an extension of existing track facilities at Holloman.

I-beam sled is installed on the new track prior to run on the new twin-railed test facility.



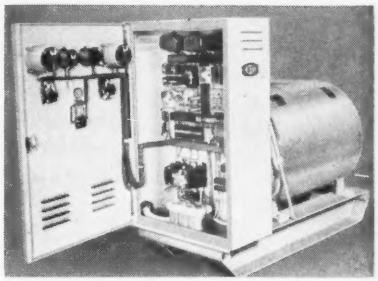
This streamlined sled is capable of taking a 200-lb payload to Mach 4 on the new track.



Astrodyne's 100,000-lb thrust Megaboom solid propellant motor, which can boost a 2000-lb payload to 1200 mph on the new facility.

The Systems Approach To

POWER CONVERSION



The 60 to 400 cycle frequency changing motor generator set and complete controls are mounted together on the skid base. This smaller type cubical contains all necessary meters, laced and channeled circuitry, motor starter with stop and start push buttons and a Kato static REGOCITER combination voltage regulator and static exciter. Kato Magtrol static regulators are manufactured for use with brushless AC generators which must have rotating exciters.

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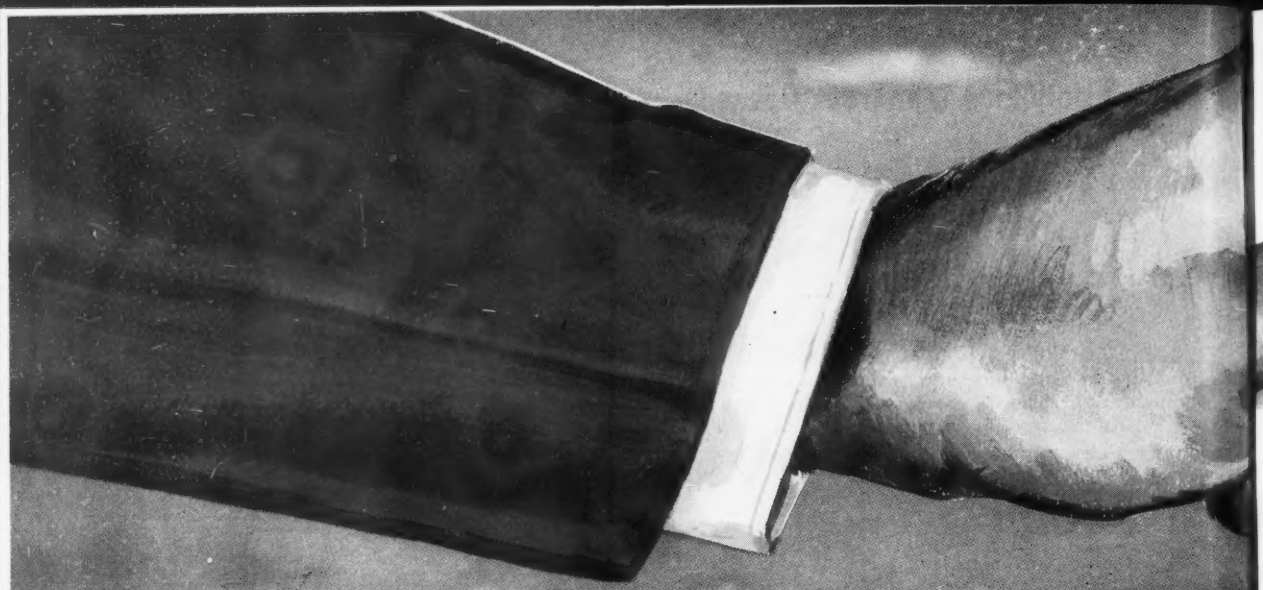

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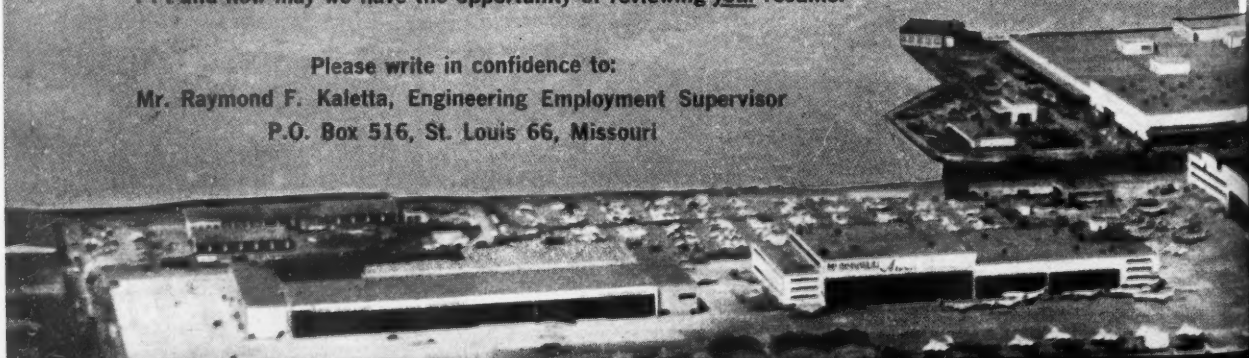

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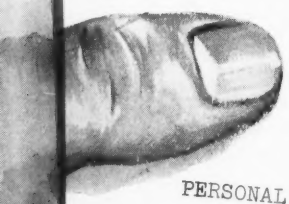


PERSONAL:

NAME - McDonnell Aircraft
ADDRESS - Beautiful suburban St. Louis, Missouri
AGE - 20 years
HEALTH - Excellent, growing with vigor and stability.
PHYSICAL APPEARANCE - 3,930,076 gross square feet of floor area dedicated to the mastery of air and space. A beautiful campus-like environment featuring the most advanced facilities for creative achievement.
SIZE - A total staff of 25,000; 4,000 of whom comprise our Engineering Divisions.

MILITARY SERVICE:

A prime contractor of U.S. Defense Department.

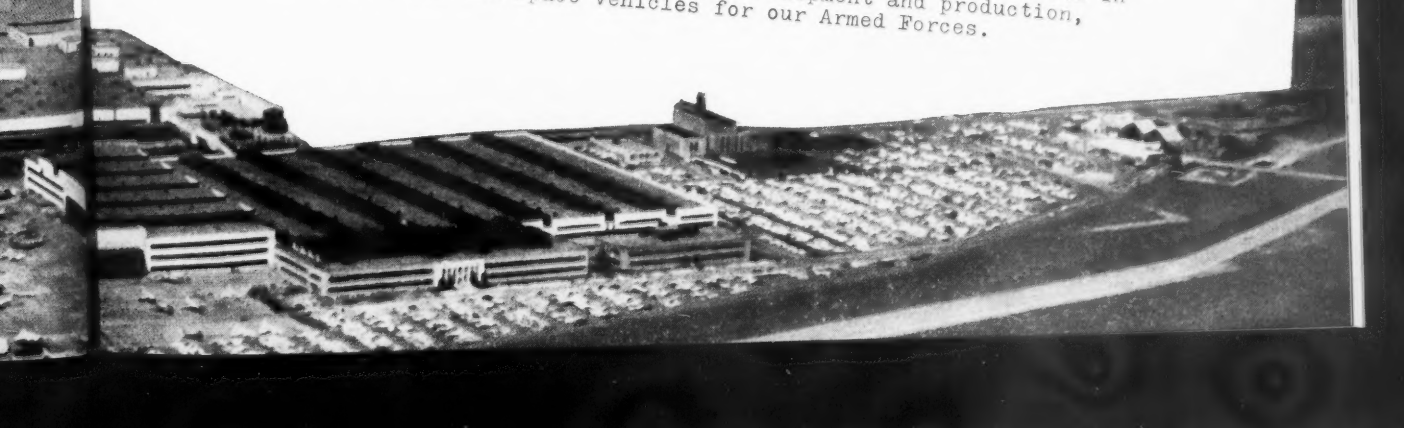
BUSINESS ACHIEVEMENTS:

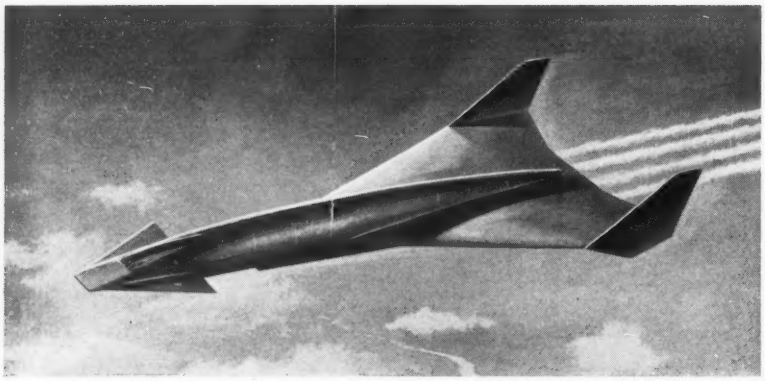
PAST - FD-1 Phantom - First all-jet airplane to take off and land on aircraft carrier.
F2H Banshee - Famous Korean War fighter jet.
Little Henry and XV1 Convertiplane - First ramjet helicopter. XV1 Convertiplane made first successful conversion from helicopter to airplane flight.

PRESENT - Talos - the airframe and power plant of this missile designed and developed at McDonnell.
F-101 Voodoo - Holder of three transcontinental speed records, the F-101B Interceptor now in quantity production.
F3H Demon - Missile carrying all weather Navy fighter now in production and fleet service.
F4H - Production award winner for Mach 2+ all weather Navy fighter.
Quail - Prime contractor for air-launched Air Force decoy missile.
Utility Jet - Company is vigorously engaged in the Air Force UCX competition for a multi-purpose, 4-jet trainer-transport. McDonnell entry will be capable of going anywhere in the world at cruising speeds over 550 m.p.h.
Electronics - Development and quantity production of an electronic automatic checkout system for 101B aircraft. This system will completely check out the many electrical and electronic systems and sub-systems within minutes.
Space Exploration - McDonnell just awarded contract by N.A.S.A. to develop and build FIRST MANNED SATELLITE CAPSULE.

FUTURE OBJECTIVES -

McDonnell will continue to diversify and intensify its efforts in all areas of engineering research, development and production, related to air and space vehicles for our Armed Forces.





1970 Transport Aircraft?

Convair, predicting that commercial transport aircraft will soon bypass the Mach 2 range, offers this conception of the supersonic airliner of the 1970's.

Micromodules Bow

(CONTINUED FROM PAGE 36)

results in an over-all reduction of 5 to 1.

Micromodules offer missile and space vehicles payload reduction without design compromise of lessening equipment reliability. Take, as an example, the miniaturized payload of the Score satellite (see page 38).

The Score communications system consisted of two 8-watt FM transmitters for voice or multichannel teletype, each weighing 2.5 lb; two 30-mw AM transmitters for beacons, each weighing 0.75 lb; two FM receivers, each weighing 10 oz; two electronic control units, each weighing 0.75 lb; and two tape recorders and playback mechanisms. RCA developed this equipment, with the exception of the tape recorders, for the Army Signal Corps.

To illustrate the micromodule potential in this application, the FM receiver and the electronic control unit were selected for consideration. The illustration on page 36 show the packaging arrangement of the Score FM receiver and its equivalent micromodular version. Specific circuit functions are integrated in four micromodules, containing such microelements as resistors, transistors, capacitors, and diodes. A resulting volume reduction of 3 to 1 with an accompanying weight reduction of 5 to 3 may be obtained. The volume and weight reductions are similar for the Score control unit.

The micromodule concept provides a natural design integration into a weapon system, such as Minuteman, consisting of both missile electronics and ground support equipment.

In the area of missile electronics it is feasible to adapt micromodules to an inertial guidance system, including the computer and the stable platform and the associated electronic circuitry. Also, various subunits of the launch control and checkout systems of the ground support equipment lend themselves to micromodule design.

Preliminary design studies of an intertial guidance computer, of which a large portion is micromodular and the remainder reflects improved high density packaging techniques, indicates a size reduction of 4 to 1.

Significant Weight Reduction

Studies on the stabilized platform on which a number of transistorized amplifiers are mounted directly on the platform gimbals, indicate that micromodular amplifier design can provide significant weight reduction. In addition, the resulting simplification of the platform electronics is conductive to improved platform performance.

The philosophy of a modern deterrent missile weapon system with its requirements of continuous alert status, instant readiness, and high reliability points out the need for hardware design fully compatible with these needs. The importance of an effective and comprehensive weapon checkout procedure is emphasized by these system requirements. Weapon system checkout must be direct and simple, ensuring return of the system to the state of readiness in the event of a malfunction. The micromodule design concept, in which a replaceable package contains a greater number of electronic functions than a conventional package of the same volume, provides for a less detailed fault-location procedure. In addition, maintenance is facilitated and a simplified logistics support is provided.

Another consideration is that the amount of hardware needed for a deterrent missile weapon system is immense. The production effort can be eased by the use of standardized building blocks. The building block characteristic of the micromodule, with its standardized structure, its circuit functional application, and its mass-production capability, clearly indicates its compatibility with this consideration.

From its inception, the micromodular concept has been planned to embrace future solid-state techniques both in the areas of advanced individual circuit components and in the so-called integrated approaches. Recent component developments, such as integrated unipolar transistors, mesa transistors, fully printed electrolytic capacitors, and negative resistance diodes, lie within the immediate scope of the micromodule program. Additional developments covered by this scope include microminiaturized magnetic memory, transfluxor, semiconductor delay line, parametric amplifier, and high voltage photovoltaic elements.

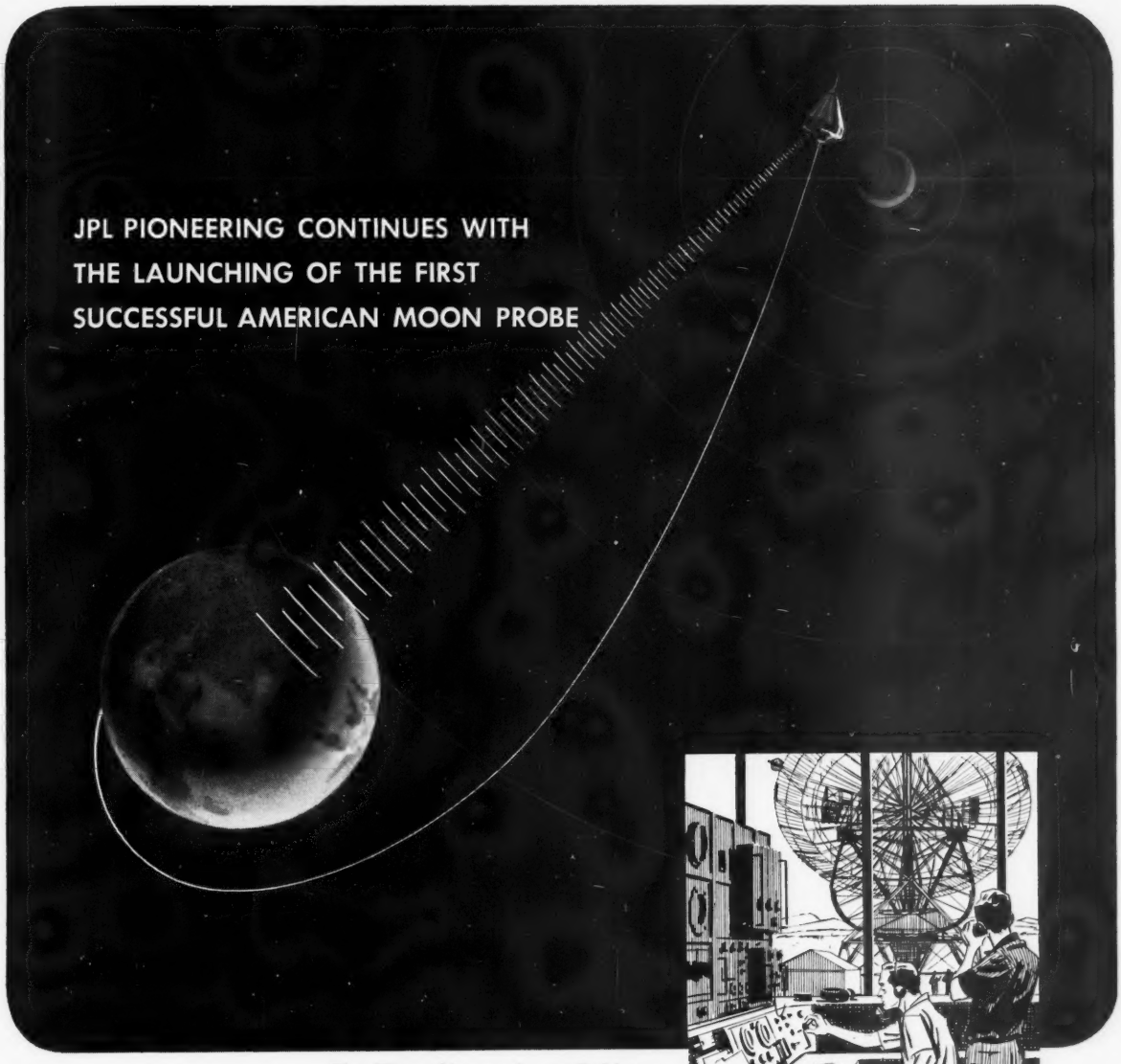
The adaptation of most basic solid-state microcircuit concepts, which integrate the functions of many conventional circuits into a single solid-state device, is readily made to standard-form microelement geometry. As new solid-state devices are developed and become available, their integration with microelements may be immediately effected.

Offers Great Potential

With this expansion of the micromodule application, complete electronic systems, including those in missiles and satellites and their related ground equipment, can be significantly miniaturized. It is recognized that in satellite application concerted miniaturization effort is needed in specific areas of telemetering, high IF frequency (2000 mc range) receivers, and high power beacons.

Recent developments, especially in solid-state functioning circuits with parts densities of over 5 million parts per cu ft, are now within the state of the art. Thus, the original micromodule packaging design goal of 250,000 parts per cu ft will be fully met, and possibly exceeded, in the design of complete systems.

NOTABLE ACHIEVEMENTS AT JPL...



The JPL tracking station at Goldstone in the Mojave Desert in California

Early on March 3, 1959, Pioneer IV space probe was launched from Cape Canaveral, Florida to become America's first deep-space vehicle capable of escaping the earth's gravitational pull. On its way past the moon and out into orbit around the sun, this new man-made planet sent back valuable information on the radiations present in space. Several Free World tracking stations clearly received its transmitted signal and helped to establish its distance, velocity, and direction.

Under the sponsorship of the National Aeronautics and Space Administration, JPL designed and built not only the conical payload of Pioneer IV but also the three upper stages of the Juno II launching vehicle, containing new high-performance JPL solid propellant rockets.

Over a year ago the same JPL team, in cooperation with ABMA, gave America its first earth satellite, Explorer I, using a similarly reliable vehicle—the Jupiter C.

Now, more advanced space vehicle programs are under way at JPL — programs which include development of guidance and propulsion systems for accurate maneuvers many million miles from the earth.

jpl

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JET PROPULSION LABORATORY

A Research Facility of the National Aeronautics and Space Administration

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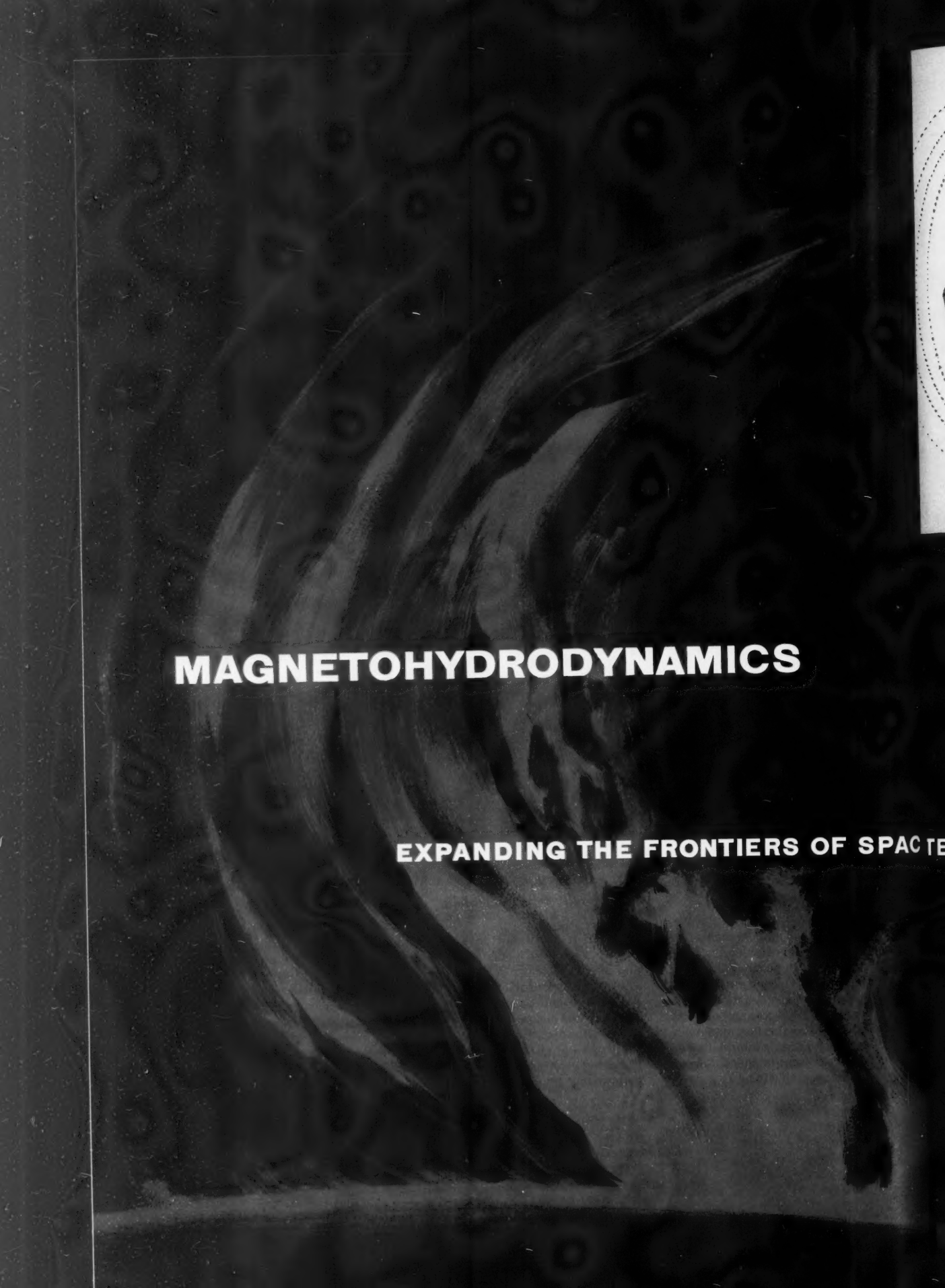
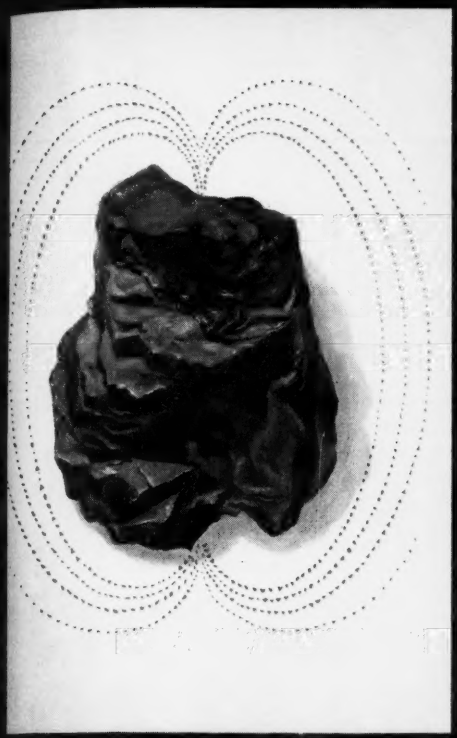

MAGNETOHYDRODYNAMICS
EXPANDING THE FRONTIERS OF SPAC TE



MAGNETOHYDRODYNAMICS: Lockheed's 3rd Annual Symposium* on this important new field—which deals with the behavior of conducting fluids in magnetic fields—attracted physicists from all over the world. As portrayed by the artist, man's earliest experiments with magnetic forces involved the use of the ancient lodestone. Solar prominences are a dramatic example of such forces under investigation today.

PAC TECHNOLOGY

Lockheed Missiles and Space Division has complete capabilities in more than 40 areas of science and technology—from concept to operation. Headquarters are at Sunnyvale, California, on the San Francisco Peninsula, with research and development facilities located in the Stanford Industrial Park in nearby Palo Alto and at Van Nuys in the San Fernando Valley of Los Angeles. A 4,000 acre, company-owned test base, 40 miles from Sunnyvale, conducts all phases of static field testing. In addition, complete flight testing is conducted at Cape Canaveral, Fla., Alamogordo, N.M., and Vandenberg AFB, Calif. as an integral part of every stage of missile and space programs at Lockheed.

The Division's advanced research and development programs now under intensive study provide a fascinating challenge to creative engineering. These programs include: man in space; space communications; electronics; ionic, nuclear and solar propulsion; magnetohydrodynamics; oceanography; computer research and development; operations research and analysis; human engineering; electromagnetic wave propagation and radiation; materials and processes and others.

Lockheed's programs reach far into the future and deal with unknown environments. It is a rewarding future which scientists and engineers of outstanding talent and inquiring mind are invited to share. Write: Research Development Staff, Dept. E-14, 962 W. El Camino Real, Sunnyvale, California. U.S. Citizenship required.

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*Copies of the proceedings of the first two symposiums were published by the Stanford University Press, Palo Alto, Calif. and are available in book form. Results of this year's symposium will be published shortly by the same house.

ARS news

Flight Testing Conference at Daytona Draws Attendance of 800

When the decision was made to organize a series of ARS special subject conferences during 1959, the expectation was that meetings of this kind would attract a relatively small attendance, at least in contrast to the two annual ARS meetings.

Consequently, the Flight Testing Conference at Daytona Beach, Fla., March 23–25, was not expected to draw an attendance of more than 500. However, much to the surprise of the national headquarters staff, and even of the conference committee, the twin attractions of an excellent program and the sunny Florida shore attracted a total attendance of 800.

John Sterner of Space Technology Labs, program coordinator for the conference, the first of any society to be solely devoted to missile flight testing, wisely decided at the outset to make the technical sessions as down-to-earth as possible, avoiding theory and concentrating instead on the practical aspects of such testing, with emphasis on test results and on mistakes which have been made in the past and ways and means of avoiding them in the future.

That this approach was successful is indicated by the many favorable comments about the conference from those in attendance. In all, there were nine technical sessions, covering such areas as ground support, data systems, countdowns, missile performance, instrumentation, flight experience, prelaunch problems, and range support. Four of the sessions, including one night session, were classified, and each drew a large attendance. The meeting concluded with a full-scale classified tour of Cape Canaveral in which 210 conference registrants participated.

The two conference luncheons and the banquet each drew a capacity audience, attracted by featured speakers David A. Young, chief of the space technology branch of ARPA; Rear Adm. John T. Hayward, assistant chief of naval operations for research and development; and Homer J. Stewart, director of program planning and evaluation for NASA.

The ground support session highlighted the relative neglect of this important aspect of flight testing, pointing up future needs and also covering such troublesome areas as high pressure helium operations and propellant handling, transfer, and storage.

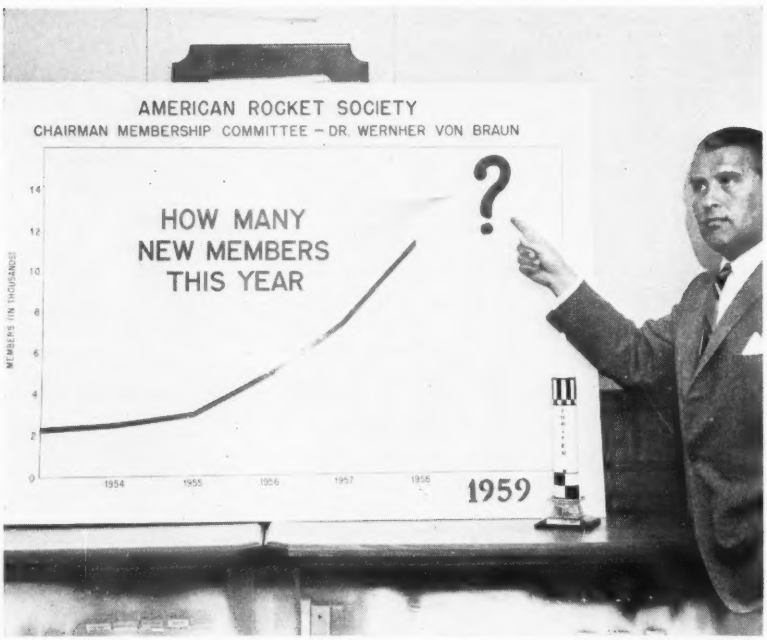
The two sessions devoted to data systems stressed the need for instantaneous systems which would keep test crews alerted to problems arising during flight tests and enable them to take preventive action in advance to prevent possible loss of the missile in flight. Authors at these sessions stressed the need for improved display systems, more advanced computer techniques and better mathematical methods of describing a missile's performance in flight.

Of special interest was a session devoted entirely to countdowns, the first of its kind ever held. Emphasis here was on automation, with John S. Harrison, Convair-Astronautics, noting (ARS Preprint No. 753–59) that all too often it is human mistakes which are responsible for firing delays. Another interesting paper at this session was that by Maj. R. F. Durbin of AFMTC on "Missile Range Meteorology" (ARS 757–59).

The secret session on missile performance centered on propulsion, guidance, and control problems as reflected in experience gathered in actual test programs. Closely allied to this was the Secret evening session on flight experience, designed to give the results of weapon system tests at the three major missile test areas—the Atlantic and Pacific Missile Ranges and White Sands. The classified instrumentation session was highlighted by a panel discussion bringing together five top IR experts and three papers on telemetry problems, while the range support session, also classified, covered such topics as range safety and recovery operations.

The session devoted to prelaunch operations, another first, produced an excellent paper by Sidney Rumbold of Aerojet on "Problems in Servicing Nuclear Rockets" (ARS 758–59), as

ARS Membership Chairman and His Charge



ARS Membership Chairman Wernher von Braun, director of development operations at ABMA, poses with a chart showing the Society's phenomenal growth during the past few years and ponders over the question of what 1959 will bring in the way of new members.

See Important IAF Announcement on Page 143

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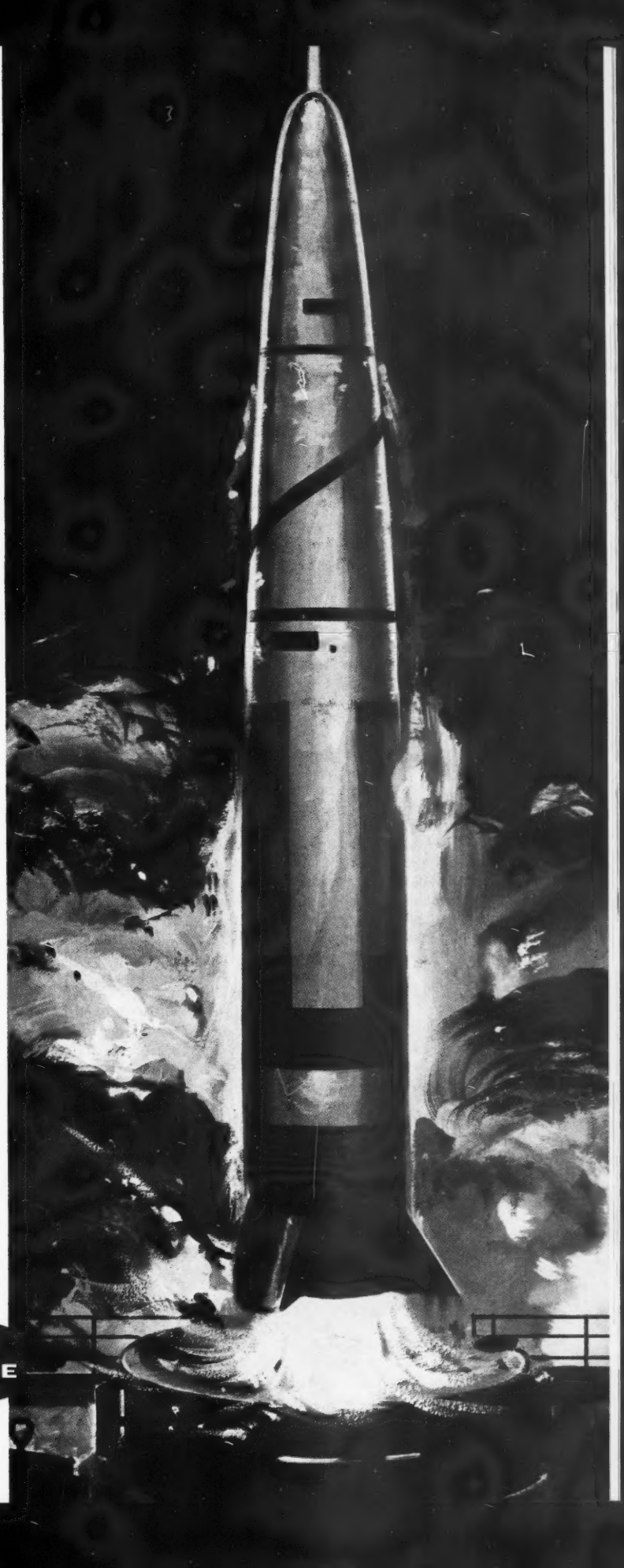

ARS 1959 Paper Deadlines

Date	Meeting	Location	*Deadline
May 25–27	National Telemetering Conference	Denver, Colo.	Past
June 8–11	Semi-Annual Meeting	San Diego, Calif.	Past
July 20–21	Propellant Thermodynamics & Handling Conference	Ohio State Univ.	May 18
Aug. 24–26	Gas Dynamics Symposium	Northwestern Univ.	June 22
Aug. 31–Sept. 5	10th IAF Congress	Westminster, London	May 15
Nov. 16–20	14th Annual Meeting	Washington, D.C.	Aug. 17
1960			
Jan. 28–29	Solid Propellants Conference	Princeton Univ.	Nov. 16

* For reviewed and approved manuscripts in the New York office. Subtract 30 days for unsolicited papers that must go through the reviewing procedure and 60 days for abstracts submitted for consideration. Send all papers and abstracts to Meetings Manager, ARS, 500 Fifth Ave., New York 36, N.Y.

well as discussions of such topics as missile handling, prelaunch preparations, and flight test simulation.

David Young was the featured speaker at the luncheon on the opening day. He devoted his talk to MRS-V (Maneuverable Recoverable Space Vehicles), noting that we will in the near future have the propulsive power to put such vehicles in space and urging that development work on them begin today so that they will be ready in three years to take advantage of advanced U.S. space capability at that time. At a press conference prior to the luncheon, Young questioned whether the U.S. was doing everything in its power today to move into space, pointing to lack of effort in the MRS-V area as a serious deficiency in our present space program. Manned vehicles of this type, he pointed out, could travel about freely at altitudes of several hundred miles, maneuvering in different orbits and serving a useful role as satellite repair stations.

Brig. Gen. John A. Barclay (USA), ABMA commander, delivered a welcoming address at the luncheon, while Byron G. McNabb of Convair-Astronautics, Florida ARS Section president, was the toastmaster.

Featured speaker at the luncheon the following day was Adm. Hayward, who devoted his address to a penetrating analysis of the challenge which faces the U.S. today. He noted that victory in the present East-West struggle "will go to the side that achieves the best possible combination of economic, political, land, sea, and air forces, and which employs that team with the greatest skill. At his press conference, Adm. Hayward revealed that the Navy plans to fire two 50-lb research satellites this year which will form the basis for eventual navigation and worldwide communications systems. Vehicles to launch the satellites have not yet been selected, he noted, but the Navy is making an effort to get the two satellites into vehicles to be used in launchings presently planned by other agencies.

Toastmaster at this luncheon was Capt. R. F. (Mike) Sellars (USN), head of the naval ordnance test unit at AFMTC, and 1958 president of the Florida Section.

Homer Stewart, feature speaker at the banquet, noted that this was the first time in the many years during which he had been coming to Florida that he had not made the trip in connection with a flight test operation. He delivered a progress report on NASA, pointing out that one of the primary objectives of the agency is the development of efficiently proportioned space vehicles to take the place of the makeshift vehicles now in use, and of precision guidance equipment which could be used in the final stage of such vehicles. Vega and Centaur will be the first vehicles which would fall into this category, he added.

Banquet toastmaster was Anthony L. Conrad, vice-president, RCA Service Co., while Brig. Gen. W. L. Rogers (USAF), deputy commander, AFMTC, introduced Dr. Stewart.

The meeting opened with a truly sensational mixer sponsored by a number of ARS corporate members on Sunday evening, March 22. The same companies also sponsored the prebanquet reception. Both drew large turnouts. Sponsors were: Aerojet-General; Avco Research & Advanced Development Div.; Bell Telephone Labs; Convair Astronautics; Douglas Aircraft; General Electric; Lockheed Missiles & Space Div., The Martin Co.; Midwestern Instruments; Norair Div. of Northrop; Pan American World Airways; Radiation, Inc.; RCA Service Co.; Space Technology Labs

Technical sessions, as well as the luncheons and banquet, were held at the Daytona Plaza and Princess Issena hotels.

The conference committee, headed by General Chairman James F. Thompson of RCA Service Co., did an excellent job of handling the unexpectedly large crowd in attendance. Especially outstanding was the work of Lt. Comdr. James G. Wilson of the Navy Polaris project at AFMTC, who handled the clearances of those attending the Classified sessions. The entire Florida Section of ARS also pitched in to get the job done.

—Irwin Hersey

Space Law and Sociology Conference Gets 1959 Meeting Calendar Off to Good Start

The 1959 calendar of ARS meetings got off to a rousing start with the first special subject conference of the year—the Space Law and Sociology Conference, held at the Carnegie Endowment for International Peace Building in New York City, March 20.

More than 100 legal experts, sociologists, congressional leaders, and UN officials attended the conference, dealing with the "International Impact of the Space Age on Society." Andrew G. Haley, chairman of the ARS Space Law and Sociology Committee and IAF president, was general chairman of the conference; Rep. Victor L. Anfuso, of the House Committee on Science and Astronautics, honorary chairman.

The meeting was divided into morn-

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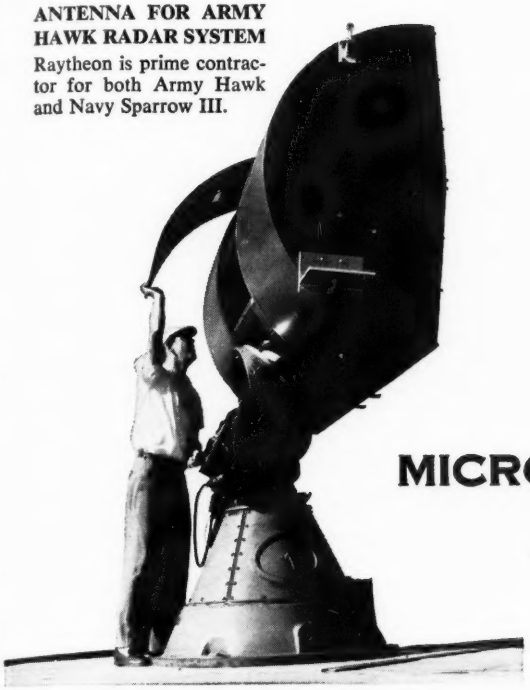

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On the calendar

1959

May 4–6	1959 Southern Metals Conference, ASM Savannah River Chapter, Bon Air Hotel, Augusta, Ga.
May 4–6	11th Annual National Aeronautical Electronics Conference, IRE, Biltmore and Pick-Miami Hotels, Dayton, Ohio.
May 4–7	5th ISA National Instrumentation Flight Test Symposium, Seattle, Wash.
May 4–7	American Meteorological Society National Meeting jointly held with American Geophysical Union, National Academy of Sciences, Washington, D.C.
May 6–8	1959 IRE Seventh Region Conference and Electronics Exhibit, Univ. of New Mexico, Albuquerque, N.M.
May 18–20	5th National Symposium on Industrumental Methods of Analysis, Houston, Tex.
May 20–22	Society for Experimental Stress Analysis 1959 Spring Meeting and Exhibition, Sheraton Park Hotel, Washington, D.C.
May 21–27	Int'l Scientific Convention and Exhibition, Institution of Electrical Engineers, Earls Court, London, England.
May 25–27	Japanese Rocket Society 1959 Int'l Symposium on Rockets and Astronautics, Tokyo.
May 25–27	**National Telemetering Conference, co-sponsored by ARS, AIEE, IAS, and ISA, Denver, Colo.**
June 8–9	Industry Missile and Space Conference, Aero Club of Michigan, Sheraton-Cadillac Hotel, Detroit.
June 8–11	**ARS Semi-Annual Meeting and Astronautical Exposition, San Diego, Calif.**
June 11–13	1959 Heat Transfer and Fluid Mechanics Institute, Univ. of Calif., Los Angeles.
June 13–23	UNESCO Int'l. Conference on Information Processing, Paris.
June 17–18	Blood Flowmeters Symposium, Univ. of Nebraska College of Medicine, Omaha.
July 20–21	**ARS Propellant Thermodynamics and Handling Conference, Ohio State Univ., Columbus, Ohio.**
July 24–26	AIEE Air Transportation Conference, in conjunction with 1959 Summer and Pacific General Meeting, Olympic Hotel, Seattle, Wash.
Aug. 9–12	ASME-AICE Heat Transfer Conference, Univ. of Connecticut, Storrs, Conn.
Aug. 18–21	1959 Western Electronic Show and Convention, San Francisco.
Aug. 24–26	**ARS Gas Dynamics Symposium, Dynamics of Conducting Fluids, Northwestern Univ., Evanston, Ill.**
Aug. 27–29	American Physical Society 1959 Summer Meeting in the West, Univ. of Hawaii, Honolulu.
Aug. 28–29	British Commonwealth Space Flight Symposium, Westminster, London.
Aug. 31–Sept. 2	4th Int'l Symposium on Free Radical Stabilization at National Bureau of Standards, Washington, D.C.
Aug. 31–Sept. 5	**10th Annual International Astronautical Federation Congress, Westminster, London.**
Sept. 9–11	Midwestern Conference on Fluid and Solid Mechanics, Univ. of Texas, Austin.
Sept. 22–24	Industrial Nuclear Technology Conference, co-sponsored by Illinois Inst. of Tech., at Morrison Hotel, Chicago.
Oct. 6–9	Int'l Symposium on High Temperature Technology, sponsored by Stanford Research Institute, at Asilomar, Calif.
Oct. 7–9	ASME-AIME Solid Fuels Conference, Cincinnati, Ohio.
Oct. 7–9	6th National Symposium on Vacuum Technology, American Vacuum Society, Sheraton Hotel, Philadelphia.
Oct. 12–14	National Electronics Conference, Co-sponsored by Illinois Inst. of Tech., at Hotel Sherman, Chicago.
Oct. 26–28	IRE Professional Group East Coast Conference on Aeronautical and Navigational Electronics, Baltimore, Md.
Oct. 26–30	1959 National Conference of the Society of Photographic Scientists and Engineers, Edgewater Beach Hotel, Chicago.
Oct. 28–29	6th Annual Computer Applications Symposium, sponsored by Illinois Inst. of Tech., at Morrison Hotel, Chicago.
Nov. 16–20	**ARS 14th Annual Meeting and Astronautical Exposition, Washington, D.C.**
Nov. 16–20	5th Int'l Automation Exposition and Congress, N.Y. Trade Show Bldg., New York, N.Y.

1960

Jan. 28–29	**ARS Solid Propellants Conference, Princeton Univ., Princeton, N.J.**
Aug. 31–Sept. 7	10th Int'l Congress of Applied Mechanics, Congress Bldg., Stresa, Italy.

ing and afternoon seminars, each devoted to the presentation of a large number of short papers covering various aspects of space flight and its broad implications. The high level of the conference was evidenced immediately after the meeting began, since the first paper was a provocative analysis of the possibility of finding life on other worlds by Harlow Shapley of the Harvard Univ. Astronomy Dept.

Other papers at the morning session were given by Jiri Nehnevajsa of Columbia Univ., who discussed space flight and the behavioral scientist; Jacek Machowski of the Polish UN Mission, who covered space law problems at the 13th session of the UN General Assembly; Rep. David S. King of the House Astronautics Committee, who talked on education in the space age; and Spencer M. Beresford, special counsel of the House Committee, whose topic was "The Basis of East-West Agreements On Outer Space."

Members of a special subcommittee of the House Committee on Science and Astronautics, named by committee chairman Rep. Overton Brooks to participate in the conference, and headed by Rep. Anfuso, also spoke briefly at the morning session.

The conference luncheon, attended by representatives of the 18 member nations of the UN Ad Hoc Committee on the Peaceful Use of Outer Space, was highlighted by addresses by Rep. Anfuso and T. F. Walkowicz, and what may well have been the briefest luncheon talk of all time—a one-line quip by Col. John P. Stapp (USAF), ARS national president.

Dr. Walkowicz, a unique combination of aeronautical engineer and investment analyst, delivered a stimulating address on the economic implications of space flight and, in so doing, proved conclusively that it is possible to spice a talk on a basically serious topic with large helpings of wit and imagination.

Among the speakers at the afternoon seminar were the Rt. Rev. Msgr. Paul H. Furfey, head of the Sociology Dept. of Catholic Univ.; Leo A. Huard, professor of law at the Georgetown Univ. Law Center; and James H. Barnett, head of the Dept. of Sociology and Anthropology of the Univ. of Connecticut.

Conference attendees were enthusiastic about the meeting; full proceedings will be published late this year.

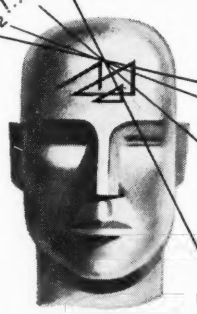
—I. H.

Ehricke Names Grey, Torda To ARS Awards Committee

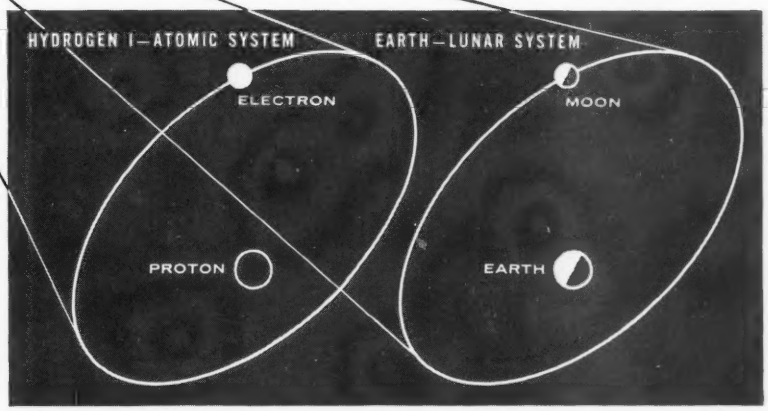
Krafft Ehricke, Chairman of the ARS Awards Committe, has appointed

ENGINEERS – SCIENTISTS

$$P(k_1, k_2, \ldots, k_m) = \frac{n!}{k_1! k_2! \ldots k_m!} p_1^{k_1} p_2^{k_2} \ldots p_m^{k_m}$$



Is order and organization in MACROCOSM and MICROCOSM an underlying principle of the universe... or does a fundamental state of randomness prevail in the cosmos as might be expressed by the multinomial formula at left?



BOLD MINDS

THROUGHOUT HISTORY..... BOLD MINDS have sought to understand the forces at work in the universe, and as they developed working hypotheses, endeavored to turn all knowledge to their own purposes, devising philosophical and mechanical systems of their own.

As old hypotheses become inadequate or untenable, thinking men devise new ones. So the concept of a "flat" world has changed to an oblate orbiting spheroid – mere speck in a vast and expanding universe; so "empty" formless space is regarded as a curved continuum occupied by random knots of turbulence (creating the new branch of mechanics – hydromagnetics).

Today new horizons of discovery and surmise arise before the speculative mind.

ENGINEERS AND SCIENTISTS AT REPUBLIC FEEL KINSHIP WITH ALL BOLD MINDS OF PAST AND PRESENT, AS THEY FACE THE EXHILARATING CHALLENGES OF CREATING VEHICLES TO FLY IN ENVIRONMENTS WHERE NEW APPROACHES IN THERMO/AERODYNAMICS MUST BE MADE...AS WELL AS APPROPRIATE PROPULSION AND ELECTRONIC SYSTEMS TO POWER AND GUIDE TRANSIT IN SPACE

Groups of Research, Development and Experimental Engineers and Scientists at Republic Aviation are now working on projects over the whole range of aeronautics and astronautics – from supersonic and hypersonic weapons systems, both manned and unmanned, to plasma propulsion and space electronics.

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Airborne Navigational Systems
Jamming & Anti-Jamming
Miniaturization-Transistorization
Ranging Systems
Propagation Studies
Ground Support Equipment

THERMO, AERODYNAMICS
Theoretical Gasdynamics
Hyper-Velocity Studies
Astronautics Precision Trajectories
Airplane/Missile Performance
Air Load and Aeroelasticity
Stability and Controls
Flutter & Vibration
Vehicle Dynamics & System Designs
High Altitude Atmosphere Physics
Re-entry Heat Transfer
Hydromagnetics
Ground Support Equipment

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MOMENT IN HISTORY

THIS IS THE "FIRST FLIGHT" of the new Air Force TITAN, America's most powerful weapon and our No. 1 challenger in the big-missile field. Time: 2/6/59—4:22 p.m. EST. The most important thing about this moment in history is not visible here--and it is this: Three years to the day from the breaking of ground at Martin-Denver, TITAN No. 1 roared into the sky. Those 36 months saw the creation of the free world's most advanced ballistic missile facility—and the development, production, testing, delivery and launching of the first of an entirely new *generation of ballistic missile weapon systems, forerunner of the Global Ballistic Missile. TITAN is the result of an advanced engineering concept—developed by Martin under the direction of the Air Force's Ballistic Missile Division of the Air Research and Development Command—which provides the most extensive pre-flight testing of components, subassemblies and full scale missiles ever undertaken. This method in the TITAN development, and in the generations of space systems to follow, may well be one of the most important single factors in speeding America's bid for space supremacy.*

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Prof. T. Paul Torda of the Polytechnic Institute of Brooklyn and Prof. Jerry Grey of Princeton Univ. to the committee.

Dr. Torda will head the group reviewing entries for the $1000 ARS-Thiokol Chemical Corp. Award for graduate students, while Dr. Grey will review undergraduate papers submitted for the $1000 ARS-Chrysler Corp. Student Award.

Entries may be obtained by writing to: 1959 Student Awards Competition, AMERICAN ROCKET SOCIETY, 500 Fifth Avenue, New York 36, N.Y. Final manuscripts must be in by Sept. 1.

SECTIONS

Central Colorado: At the January meeting, guest **Robert L. Zimmerman** talked on "Kilowatts to Megawatts, Power Generation for Space," discussing the power needed for coming space vehicles and how that power may be provided with chemical batteries, solar cells, small nuclear reactors, and thermoelectric generators. He noted that power requirements below 100 watts can be met with solar cells, requirements above 140 watts by nuclear systems, and requirements between these values by chemical systems.

The February meeting, one of the more ambitious held thus far, saw 260 members and guests gather at the U.S. Air Force Academy to tour its grounds and installations. After a buffet dinner, the meeting was joined by 400 cadets. This group heard the guest speaker of the evening, the **Honorable Richard E. Horner,** assistant secretary of the AF for R&D, review the nation's ballistic missile program and associated projects. Mr. Horner cited the close cooperation between scientists and military experts as a major reason for the rapid and efficient maturing of the ballistic missile program. He pointed out that Titan had been completely successful on its first flight test. Concerning Atlas, he remarked, "The final operational configuration will be tested this year and we have every confidence that the missile will be operational before the year is out." Reflecting on opinion shared by the membership, he concluded by saying, "The community of American rocketry, I am sure, is destined to take a larger and more prominent place in our national affairs in the coming years."

—Robert W. Rhoads

Delaware: The section received its charter at a special meeting held in conjunction with banquet night of the Delaware Council of Engineering Societies during National Engineer's Week Feb. 22 to 28. At the banquet, held in the Gold Ballroom of the Hotel Du Pont, James J. Harford, ARS ex-

And Welcome Delaware

James Harford, ARS executive secretary, presents Delaware charter to the new section's president, Horace I. Bomar Jr., in ceremonies held in conjunction with the Delaware Council of Engineering Societies' banquet (below) during National Engineer's Week. Onlooker about to say a word is Kurt Stehling, former ARS director, who was featured speaker at the banquet.

Preface to Laurels

The Honorable Richard E. Horner (left), assistant secretary of the Air Force for research and development, chats with AF Academy superintendent Maj. Gen. James E. Briggs and Mrs. Briggs before addressing a meeting of the Central Colorado section, which he lauded for its growth and activities.

ecutive secretary, presented the charter on behalf of the society. The featured speaker of the evening was former ARS director **Kurt Stehling,** who discussed aspects of engineering for space projects.

Holloman: At the February dinner meeting, **Maj. Gen. W. E. Laidlaw,** commander of White Sands Missile Range, described the history and present organization of this vast missile testing complex, showing how it had developed into an interservice facility. The DOD integration agreement under which the range functions assigns specific responsibilities to each service. The Army, for instance, is charged with providing instrumentation and missile recovery for all users. Air Force responsibilities include flight support and drone operations. On the whole, Gen. Laidlaw said, the arrangement has worked very smoothly and has promoted progress on R&D projects.

One of the key figures in the Holloman section is **Frank A. Smith Jr.,** business manager of the *Holloman Monthly News Bulletin.* His responsibilities are to make sure the publication remains financially healthy, and this he does with a keen ability to negotiate with men from many walks of life. A specifications engineer with Lockheed Missile Systems Div. at Holloman, he is officially engaged in work on the sophisticated X-7A and Q-5 programs, with the *News Bulletin* an off-duty activity. Under his guidance, the paper has grown into a highly successful section activity.

New York: Members and guests at the March meeting, held at the World Affairs Center in New York, heard **Capt. R. C. Truax,** USN, 1957 president of ARS, discuss amateur rocket enthusiasts—their numbers, characteristics, motivations, and potential as professional engineers and scientists. He also showed films and slides of steam rocket launchings at Wallops Island and exhibited a homebuilt steam rocket. The meeting concluded with a lively floor discussion of the virtues of amateur rocketry.

Southern California: In the February meeting, held at the Carolina Pines in Los Angeles, members and guests heard **Richard D. De Lauer,** author of the book, "Nuclear Rocket Propulsion," and associate director of Space Technology Lab's vehicle engineering lab, discuss the development and flight testing of Pioneer I, which reached an altitude of 80,000 miles on Oct. 11, 1958. Besides his very interesting talk, Dr. De Lauer showed a film of the flight and answered questions on unclassified aspects of the probe.

—Eric Burgess

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Kansas City Section Officers

First officers and directors of the new Kansas City Section face the future with confidence: From left, R. W. Kunkle, director; William Schultz, director; Paul Klevatt, secretary; Ralph DeRouth, director; Willard Bull, treasurer; Alan Pittaway, president; and Lloyd Elrod, vice-president. Not in the picture is Raymond Mentz, the fourth director.

Southern Ohio: Members and guests at the March meeting heard from guest **Harald J. von Beckh** on "The Physiological Effects of Weightlessness." Dr. von Beckh, who is director of the subgravity program at the Aeromedical Field Lab's space biology branch, explained what has been learned of pre- and post-weightlessness in aircraft studies at Holloman. He illustrated his comments with several very interesting movies of actual tests.

—I. E. Kanter

St. Louis: The following newly elected officers were presented to the membership at the February meeting: James N. Holsen, president; Lawrence R. Maisak, vice-president; Robert H. Damon, second vice-president; Albert E. Cohen, secretary; and F. Allen Heininger, treasurer.

Guest speaker of the evening was **John H. Bonin,** associate director of Chicago Midway Laboratories' Engineering Division, who discussed the behavior of material under high heat fluxes. With the aid of movies and slides, Bonin described the heating of materials with plasma jets and gave test results for some materials. The plasma jets used by his laboratory produce temperatures from 3000 to 15,000 K.

—Albert E. Cohen

Welcome Palm Beach

ARS director Krafft Ehricke presents charter for new Palm Beach Section to its first president, Henry J. Barten, at recent ceremonies.

STUDENT CHAPTERS

Oklahoma: The chapter received its charter in a meeting February 10. New officers presented to the membership were Robert Nerem, president; William Campbell, vice-president; Walter Smith, secretary; Roger Long, treasurer; and Melvin Rogers, St. Pat's council representative. The program for the charter night meeting included three Douglas Aircraft Co. movies on Nike, Honest John, and Thor.

In the first of two March meetings, the members had the pleasure of hearing **Richard Bilmore** of Douglas discuss "Considerations of Lunar Impact." The second meeting featured a talk by **Conrad Neal** of the U.S. Naval Ordnance Test Station, China Lake, Calif., on Sidewinder. Neal is currently in charge of the Sidewinder guidance and control system. He described the functioning of the missile, showed a movie of it in action, and demonstrated a working model of the guidance package.

The chapter has increased by 20 new members in February which shows the interest in ARS on the campus.

—Robert M. Nerem

Texas Univ.: The feature of the February meeting was a talk by **J. W. Wiggins,** assistant manager of Thiokol's Redstone Div., on "Control of Solid Fuel Characteristics." As part of this presentation, he showed a film on solid propellant development techniques used by Thiokol.

The chapter was fortunate to have **Fred C. Jonah** of Chance Vought present at this meeting. Dr. Jonah, who returned to Chance Vought in February after a leave of absence to teach at the Univ. of Texas, was presented a plaque by the chapter in token of his help and patience in organizing the group.

The chapter officers are looking forward to accepting an invitation to the North Texas Section in the near future. Our officers—Jim Infante, president; Fred Beckner, vice-president; Leroy Becker, secretary; and Bruce Bain, treasurer—will be returning the visit of several members of that section who visited Texas Univ.'s charter meeting.

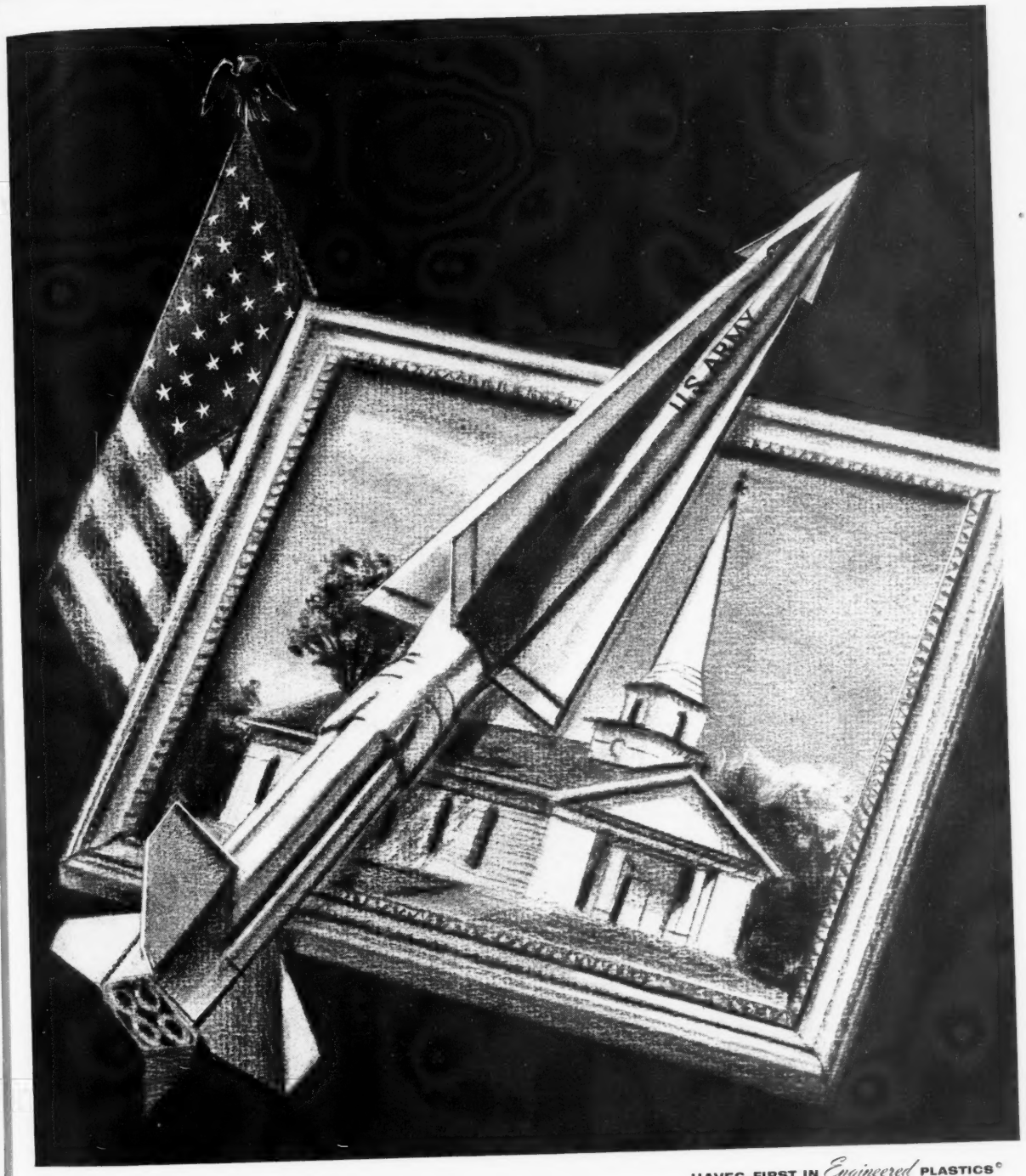
Membership continues to grow, with more than a dozen new applications this school semester.

—Leroy H. Becker

TECHNICAL COMMITTEES

Physics of the Atmosphere and Space: Milton Greenberg, president of Geophysics Corp. of America has been named chairman of the Physics of the Atmosphere and Space Committee. Named to serve on the committee are: Warren W. Berning, Aberdeen Proving Ground; Herbert Friedman, NRL; Joseph Kaplan, Univ. of California; Ward C. Low, ARPA; Homer E. Newell Jr., NASA; Col. Frederic C. E. Oder, BMD; Norman J. Oliver, AFCRC; Walter Orr Roberts, Univ. of California; Shirleigh Silverman, ONR; William J. Stroud, Army Signal R&D Lab, Ft. Monmouth, N. J.; Fred L. Whipple, Smithsonian Astrophysical Observatory; John W. Townsend Jr., NASA.

Milton Greenberg



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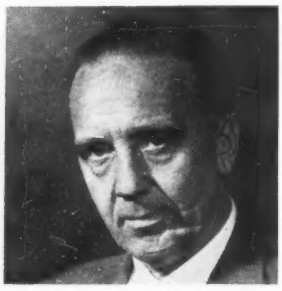
Logistics and Operations: Kurt H. Debus, director of ABMA Firing Lab, Huntsville, Ala. will serve as chairman of the Logistics and Operations Committee. Dr. Debus has named the following members to the committee: Chauncey J. Hamlin Jr., North American Aviation; Herbert L. Karsch, General Motors Allison Div.; Maj. Gen. John B. Medaris, Redstone Arsenal; Robert B. Rypinski, Chrysler Missile Div.; Capt. Robert F. Sellars, AFMTC, Patrick AFB; and Maj. Gen. Donald N. Yates, AFMTC, Patrick AFB.



Kurt H. Debus

Space Law and Sociology: Makeup of the committee has been announced by committee chairman Andrew G. Haley, ARS General Counsel and IAF President. Members are: Sen. Clinton P. Anderson; Rep. Victor L. Anfuso; Rep. Leslie C. Arends; Rep. Perkins Bass; Ralph E. Becker, Brookhart, Becker & Dorsey, Washington, D.C.; Henry E. Billingsley, NASA; Gordon Browder, Montana State Univ.; Spencer M. Beresford, House Committee on Science and Astronautics; James H. Barnett, Univ. of Connecticut; Sen. Howard W. Cannon; Rep. Emanuel Celler; Harold T. Christensen, Purdue Univ.; Carroll D. Clark, Univ. of Kansas; Rep. William C. Cramer; Donald R. Cressey, Univ. of California; Joseph R. Crowley, Fordham Univ.; Rep. Emilio Q. Daddario; Samuel E. Eastman, MIT; Clark M. Eichelberger, American Association for the UN, Inc., N.Y.C.; Robert E. L. Faris, Univ. of Washington; George J. Feldman, N.Y.C.; Rep. Gerald R. Ford; Rep. James G. Fulton; Rt. Rev. Msgr. Paul Hanly Furfey, Catholic University of America; Eilene Galloway, Senate Committee on Aeronautical and Space Sciences; Harold L. Geisert, George Washington Univ.; James S. Hanrahan, Holloman AFB; Orlando John Hollis, Univ. of Oregon; Rep. Ken Hechler; Walter Hirsch, Purdue Univ.; Sen. Thomas C. Hennings Jr.; Leo Alvert Huard, Georgetown Univ. Law Center; William A. Hyman, N.Y.C.; Ralph R. Ireland, Univ. of Arizona; Marshall E. Jones, Univ. of Wyoming.

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Andrew G. Haley

Clement S. Mihanovich, Saint Louis Univ.; Rep. Erwin Mitchell; Rep. Walter H. Moeller; Rep. William E. Miller; Elio D. Monachesi, Univ. of Minnesota; Albert Morris, Boston Univ.; Sen. Karl E. Mundt; Smithmoore P. Myers, Gonzaga Univ.; Jiri Mehnevajsa, Columbia Univ.; E. William Noland, Univ. of North Carolina; E. Pepin, McGill Univ.; John Ritchie III, Northwestern Univ.; Rep. Peter W. Rodino Jr.; Harold W. Saunders, State Univ. of Iowa; Frank Simpson III, Sheppard, Mullin, Richter, Balthis & Hampton, Los Angeles; Reynolds C. Seitz, Marquette Univ.; Harlow Shapley, Washington, D.C.; Charles S. Sheldon II, House Committee on Science and Astronautics; Rep. B. F. Sisk; Raymond E. Sletto, Ohio State Univ.; Rep. H. Allen Smith; Robert E. Sullivan, Montana State Univ.; Frank R. Swaney, Chrysler Corp.; Paul W. Tappan, New York Univ.; Paul A. F. Walter Jr., Univ. of New Mexico; Rep. Leonard G. Wolf; Philip B. Yeager, House Committee on Science and Astronautics; Kimball Young, Northwestern Univ.

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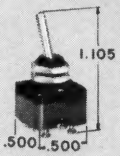

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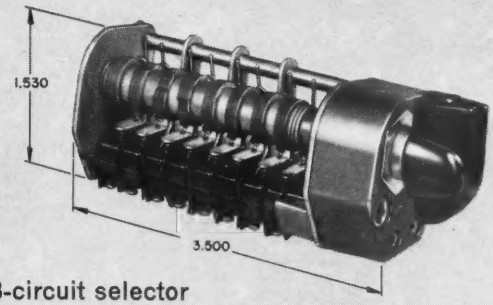

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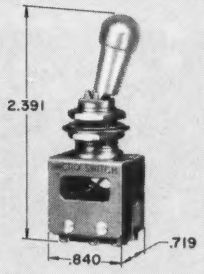

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Pictorial highlights of

Authors and session chairmen and vice-chairmen pose after authors' breakfast at the Daytona-Plaza Hotel. John Sterner of Space Technology Labs, program coordinator for the conference, is at far right in front row.

Attendance of 800, considerably higher than had been anticipated, at ARS Flight Testing Conference at Daytona Beach, Fla., March 23–25, placed heavy burden on registrations staff.

Lt. Comdr. James G. Wilson (center foreground), Navy Polaris Project Officer at Cape Canaveral, did yeoman work in making clearance procedure at the conference as painless as possible.

Head table at the banquet. Left to right, John Sterner; B. G. MacNabb, Florida Section President; G. T. Willey; Howard Seifert, ARS national vice-president; James G. Thompson, conference general chairman; guest speaker Homer J. Stewart of NASA; A. L. Conrad; Brig. Gen. W. L. Rogers (USAF); R. S. Mitchell; Capt. R. F. Sellars (USN), 1958 Florida Section president; Brooks Morris, ARS national program chairman; and W. F. Sparks, Florida Section treasurer.

Daytona conference

Two outstanding high school science students, part of a selected contingent invited to the conference by the ARS Florida Section, discuss a technical paper.

Seated on dais at March 24 luncheon are (left to right) James J. Harford, ARS executive secretary; Lt. Comdr. James G. Wilson (USN), Florida Section secretary; Martin Summerfield, ARS JOURNAL Editor and national board member; Rear Adm. John T. Hayward, guest speaker; Capt. R. F. Sellars (USN); Howard Seifert; K. M. McLaren; and G. Edward Pendray, ARS founding member.

David A. Young of ARPA, luncheon speaker, makes a point as (left to right) Lt. Col. P. B. Peabody (USAF), Florida Section vice-president; John Sterner; Col. John P. Stapp (USAF), ARS national president; and B. G. MacNabb pay close heed.

In featured roles at the conference were (left to right) Anthony L. Conrad, vice-president, RCA Service Co., banquet toastmaster; Brig. Gen. W. L. Rogers, (USAF), vice-commander, AF Missile Test Center, who introduced the banquet speaker, Homer J. Stewart of NASA; Brig. Gen. John A. Barclay, ABMA commander, who delivered the welcoming address; and luncheon speakers David A. Young of ARPA and Rear Adm. John T. Hayward, assistant chief of naval operations.

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Score Satellite

(CONTINUED FROM PAGE 39)

vacuum tubes and delivered 8 watts at 132 mc. A "handie talkie" FM transmitter was repackaged, and a high power output stage added. Repackaging was required in order to minimize effects of the intense vibration during launch and to rapidly conduct the heat of the vacuum tubes to a common heat sink where it might be radiated into space.

The 30 mw, 108 mc/s beacon was quite similar to the one used in Explorer I. It was transistorized and used one channel of FM-AM telemetry to transmit variations in the temperature of the electronics package or the missile (pod) skin.

The miniature tape recorded was designed and constructed entirely at the Signal Lab. The transistorized recorder electronic circuitry consisted of separate recording and playback amplifiers and an erase circuit. An "endless," or continuous, loop of mylar tape, 75 ft long, with a speed of $3^3/_4$ ips, completed a record or playback cycle in 4 min. Two heads were used, an erase head and a combination record/playback head. The tape transport mechanism was pressurized for reliable operation of the DC motor. In addition, the "endless" tape tended to jam on its transport without a gas (air or nitrogen) to lubricate it. The tape had a short ($1/_2$-in.) metallic section which momentarily completed an electric circuit after a 4-min tape cycle. This, in turn, notified the "brains" of the satellite, the control unit, to place the system in standby automatically.

The transistorized control unit used special notch filters to detect the various tones used to command the satellite to operate in its different modes. There were three operational modes, plus standby. On the appropriate ground command to record or playback, the satellite would store information broadcast to it or transmit back previously stored information. This method of delayed transmission is used to route messages between locations on earth which cannot "see" the satellite simultaneously. The real-time command directed the satellite to operate as an instantaneous radio relay station between ground sites separated by thousands of miles. Normal radio relay stations are separated by about 30 miles. The fourth mode of operation, standby, turned off all equipment except the tracking beacon which operated continuously and the receiver which reverted to battery saver operation.

The actual implementation of the various operational modes was further complicated by the comparatively short time cycle, 4 min per usable pass, and by the requirement for the electronic package to automatically revert to standby when out of sight of the ground stations. Valuable battery life would be lost if the transmitter or recorder were accidently left activated for even a single 100-min orbit around the earth.

For the record and playback modes of operation, powersaving latch relays were used to switch to the desired mode upon ground command at the start of the satellite pass. At the conclusion of the 4-min tape cycle, the metallic strip momentarily completed the circuit unlatching the relays. For real-time operation, a conventional relay with a continuous tone was used, since transmission time was variable. If latch relays were used, the additional ground command for standby operation would require additional circuitry. Furthermore, through human error, the command might be sent after the range was too great for the tone to be detected. Therefore, the system was designed such that absence of the continuous tone caused the standby condition.

A transistorized DC to DC converter was used to raise the voltage of the power supply battery (18 volts) to the proper plate voltages for the tubes (135 and 270 volts). The converter was a static type with no moving parts and excellent reliability. The circuit was of the common emitter type. A ripple frequency of 2500 cps was used in order to limit the size and weight of the filter components. The relatively high conversion efficiency, about 82 per cent, further minimized the design requirements of the power supply.

Since the satellite was expected to be in orbit less than a month (it actually orbited 35 days), a nonrechargeable, high capacity chemical battery system was used, rather than a costly and heavier solar converter supply with rechargeable nickel cadmium cells. Mercury (mercuric oxide) batteries, although superior at higher temperatures, had a lower capacity (watt-hours per pound) than the zinc-silver oxide batteries. The latter type was therefore selected.

Again, the short development period dictated modification of an existing design with similar requirements. This design did not have the proper cell sizes to permit an efficient, minimum weight power supply using cells with varying ampere-hour capabilities. In order to utilize the available 50 amp-hr cells, a tapped battery was used. The low voltage cells common to all circuits were designed to operate only as long as the satellite itself, an estimated 21 days. Zinc silver oxide cells are in-

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operative in a vacuum since the liquid electrolyte evaporates. Therefore, the hydrogen gas emitted by the discharging cells was used to provide a positive pressure within a sealed container. A release valve prevented excessive pressure buildup.

The extremely short time schedule permitted for completing the project led to an early decision to modify existing designs of slot antennas built specifically for the Atlas. New cavities and feeds had to be built, of course, for the particular operating frequencies. Due to the odd shape of the Atlas missile—odd from an antenna standpoint, at least—pattern irregularities were expected. The missile, some 85 ft long by 10 ft in diam, appeared to radiate like a long wire antenna, with resultant nulls in the satellite antenna pattern. The fades experienced at the ground sites were directly dependent upon the slow tumble rate of the satellite, estimated to be less than 1 rpm. The system was designed with sufficient margin above threshold, however, to compensate for most of these nulls.

Environmental Considerations

A thorough discussion of the design problems associated with the communications satellite must include some of the environmental conditions not normally associated with ground-based equipment. The temperature of the satellite is determined by the thermal radiation properties of the surface, the amount of internally dissipated power, and orbit geometry. The incoming radiation consisted of both direct and reflected (from the earth) solar radiation as well as thermal radiation from the earth. Radiation from the stellar background was considered negligible. Outgoing radiation was determined by the emissivity and temperature of the vehicle's surface.

The highly polished stainless-steel skin of the Atlas was expected to fluctuate about a temperature near 300 F. The transistors and batteries limited the operating temperature range of the communications equipment to 40 to 120 F. The magnesium pod cover was therefore coated with an eridite finish providing the proper absorptivity to emissivity ratio for an average ambient of 80 F. The highly polished canisters housing the equipment were mounted on fibreglass-foam mounts to keep the hot missile skin thermally isolated from the equipment proper.

In addition to the thermal problem, the intense vibration in the 5–2000 cps region required special fabrication methods to insure against failure during launch. Actual design require-

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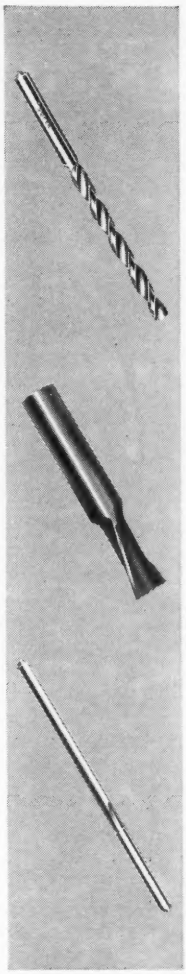
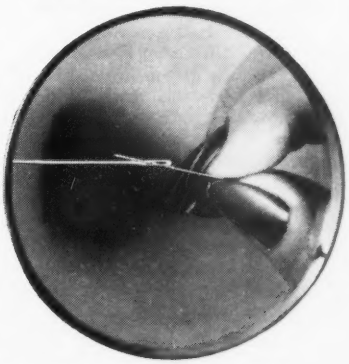


.0135 up on Drills
.032 up on End Mills
.041 up on Reamers



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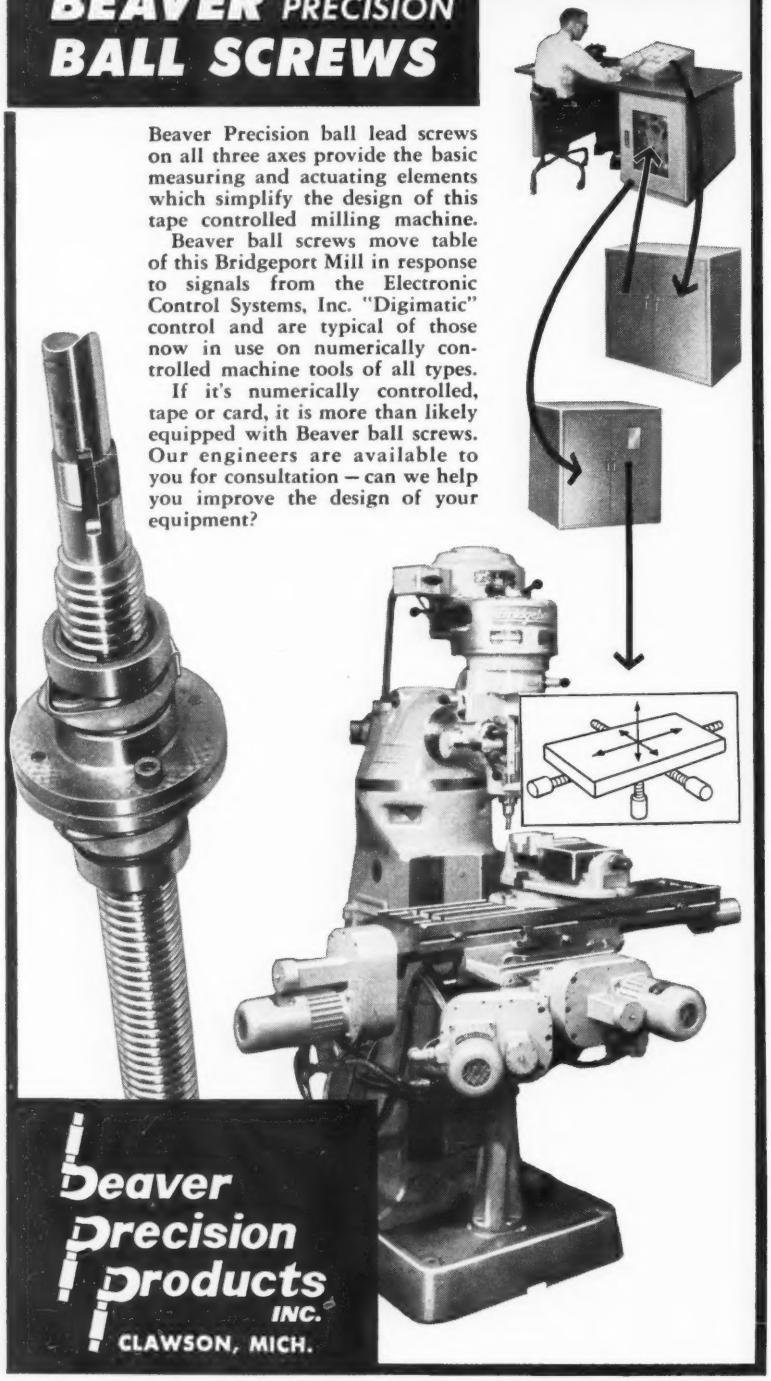
Beaver Precision ball lead screws on all three axes provide the basic measuring and actuating elements which simplify the design of this tape controlled milling machine.

Beaver ball screws move table of this Bridgeport Mill in response to signals from the Electronic Control Systems, Inc. "Digimatic" control and are typical of those now in use on numerically controlled machine tools of all types.

If it's numerically controlled, tape or card, it is more than likely equipped with Beaver ball screws. Our engineers are available to you for consultation – can we help you improve the design of your equipment?



Beaver Precision Products INC.
CLAWSON, MICH.

ments were for the equipment to withstand 10-g acceleration from 20 to 2000 cps and $^1/_4$-in. excursion from 5 to 20 cps. Most of the electronic assemblies were coated with a conformal resin coating. All of the major assemblies (receiver, transmitter, etc.) were further encapsulated in an isocyanate foam poured into place. These materials held the parts firmly in place and also conducted the heat away better than a vacuum would. Printed wiring was used in most units to further reduce the effects of vibration.

One System Failed

Two identical packages were flown to increase the reliability of the system. This redundancy proved to be vital to the ultimate success of the experiment, since one of the systems failed shortly after launch. Unfortunately, the failure occurred in the particular system that was "interrogated" (directed to the playback mode of operation) on the first pass over the California ground station. Succeeding orbits passed westward over the Pacific Ocean, moving away from the U.S. mainland, until 2:10 p.m. the next afternoon, when the satellite first passed within line of sight of the Canaveral station. It was for this reason that the President's message was not successfully broadcast from the satellite until the day after launching. The Canaveral site was originally scheduled to operate only as a countdown checkout station, and therefore had only fixed low gain antennas compared to the higher gain steerable antennas at the selected ground sites. This contributed to the poor quality of the first recording sent to local radio and television stations. In addition, the original tape recording was recorded and patched over telephone lines several times prior to actual broadcast to the public.

The ground station complement included a maintenance truck, power units, an AN/GRC-26 high frequency radio set, and a 35-ft semitrailer for the main communication system. A block diagram of the ground station equipment appears on page 39.

The ground station included the operating and standby transmitting and receiving equipment necessary for communicating with the satellite and tracking its beacon; two communications transmitters and receivers (each capable of operating on two frequencies); two beacon receivers; and two control units.

A special "fade filter" was incorporated in the system. This was a three-channel electronic switch coupled to the receiver output and a

90 seconds of inferno

A rocket engine capable of more than 50,000 lbs. of static thrust, developed and built by Reaction Motors Division of Thiokol Chemical Corporation, will soon send the fabulous X-15 searing into outer space. To protect the engine from its own fierce blast, key metal surfaces are coated with ROKIDE "Z" coating.

...but ROKIDE* Coating will protect the X-15's engine during critical burning time

As the manned X-15 bores into the sky for 100 miles or more in its forthcoming tests, rocket-powered flight will last only for about a minute and a half. However, protecting the engine from the tremendous heat and erosive force of its propellants for even that brief span posed a major design problem. Engineers solved it by coating critical metal surfaces with ROKIDE "Z" zirconium oxide — one of today's most rugged refractory materials.

This is typical of the new and challenging requirements which all three types of hard, crystalline ROKIDE spray coatings ("A", "ZS" and "Z") are meeting in the ever-expanding air and space programs. These outstanding members of Norton Company's large family of refractory materials, as well as other experimental coatings such as chrome oxide, spinel, etc., are providing protection against high heat and abrasion, corrosion and severe thermal shock in supersonic aircraft, missiles and rockets.

Norton Company maintains ROKIDE coating facilities on both coasts: at the main plant in Worcester, Mass., and at its plant in Santa Clara, California. For details, write NORTON COMPANY, Refractories Division, 962 New Bond St., Worcester 6, Massachusetts.

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missile connectors & assemblies

Skill in application engineering, production facilities and experience geared to short or long runs, a proved reputation for reliability—these are AMPHENOL's special capabilities in missile components. The assembly illustrated above reflects these capabilities.

This assembly has four AN/MS "E" connectors wired into a 83 contact shear-type connector and is being supplied in quantity for a production missile. Electrical connection between missile and ground support equipment is provided until the instant of launch when a 3500 pound maximum shear force shears all 83 contacts. All connectors are potted for optimum reliability.

Interstage connectors, umbilical breakaways, internal components and connectors for ground support equipment are now being manufactured for many missile projects. Inquiries on AMPHENOL's special capabilities in this field are invited.

AMPHENOL CONNECTOR DIVISION

Amphenol-Borg Electronics Corporation CHICAGO 50, ILLINOIS

dual channel magnetic tape playback. Its function was to sense the received signal and indicate that (1) operation was normal; (2) the signal from ground to satellite had failed; or (3) the signal from satellite to ground had failed.

Telemetered temperature data from the satellite was received as amplitude modulation on the (nominal) 108 mc/s beacon carriers. The modulation frequencies, calibrated as a function of temperature, were read through the R-390A receivers to an electronic counter. The counter was also used in conjunction with a frequency standard and WWV for checking operating frequencies.

The control unit generated the tone cues which commanded the satellite to either record, playback, or relay. In addition, it ran the required sequential switching actions to make the operation of the ground station almost automatic. All of the input and output circuits of the various equipments were connected to the patch panel at the operating position. Here the operator could conveniently make connections to the equipment required for any type of operation.

Permanent Record Made

Both magnetic tape and pen recorders were installed so that a permanent record of all pertinent data could be made. The dual channel tape recorder recorded the satellite's transmissions on one channel and the operator's comments and time signals on the other channel. The two-channel pen recorder was used to record the receiver AVC voltages and time signals.

Power to the ground stations was supplied by one of a duplicate pair of 15-kw diesel engine-driven generators, in a three-phase, 208-volt system.

To receive the omnidirectional transmission from the satellite, a circularly polarized ground antenna system was desirable. Approximately 16-db gain was required near 150 mc with correspondingly less at the 108 mc/s beacon frequency. A phased array of four helix antennas was used. The four elements, each about 12 ft long by $2^1/_2$ ft in diam, were mounted on a 13-ft square ground plate. The antenna orientation system was semi-automatic. Azimuth and elevation were selected from an operating position within the shelter by a servo loop controlling a modified searchlight pedestal—the familiar type associated with gala Hollywood premiers. Sensing of received signals level indicated when the antenna was pointed in the right direction. A filter at the antenna separated the 108-mc beacon fre-

quency from the 132- and 150-mc communication frequencies.

In conclusion, the few weeks of experimentation were completely successful. All four ground stations received the prerecorded Christmas message as well as transmitting and receiving new voice and teletype messages. Never before in history did a single hop repeater in these frequencies provide communications between stations separated as far as the California and Georgia sites. Although elementary, the Score satellite fulfilled its mission effectively. Future satellites of the courier type will be highly advanced versions of the Score equipment, with greatly increased information capacity, solar energy conversions systems, longer life, and high reliability. The possibilities are limitless. Conceivably, courier satellites can provide message and television transmission between any parts of the world, however remote, as the missile and satellite art advances.

Microminiaturized Payloads

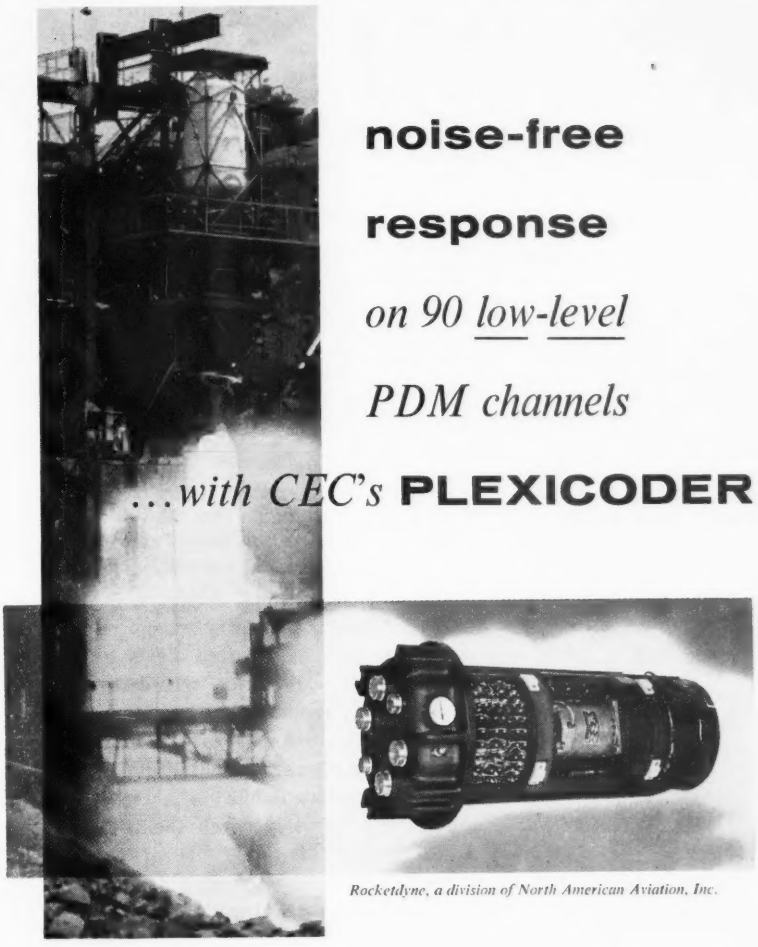
(CONTINUED FROM PAGE 20)

with good reliability than are smaller ones. Information produced by a small instrument in a short time can in some cases be just as meaningful as that produced by a large instrument operating for a long time. A set of small payloads, each specifically designed to probe a particular aspect of the space sea, can often do a better and more reliable job than can a single, multipurpose, all-or-nothing gadget, since a variety of orbits can be employed, a sequence of times can be tried, and later instruments can incorporate knowledge gained from earlier discoveries.

Payloads in 1-to-20 lb Class

In the future, I think we shall increasingly find important uses for very tiny space payloads—I mean units in the 1- to 20-lb class. Such devices will ride in vehicles whose weights range from perhaps 500 up to some 20,000 lb. These vehicles can be designed for launching from the ground or from high flying aircraft—in any direction, at any time, and from any place an aircraft can fly.

When perfected for mass production, the vehicles should cost some $2 to $10 per pound. At these prices, and in modest size, vehicles with microminiaturized instrument payloads will bring an active space research program within the reach of the scientists of any laboratory or nation.



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The PLEXICODER utilizes simple oscillograph-proved techniques for adjustment and calibration. It is designed for a minimum of 1000 service-free hours of operation. Call your nearest CEC sales and service office for full information, or write for Bulletin CEC 1599-X13.

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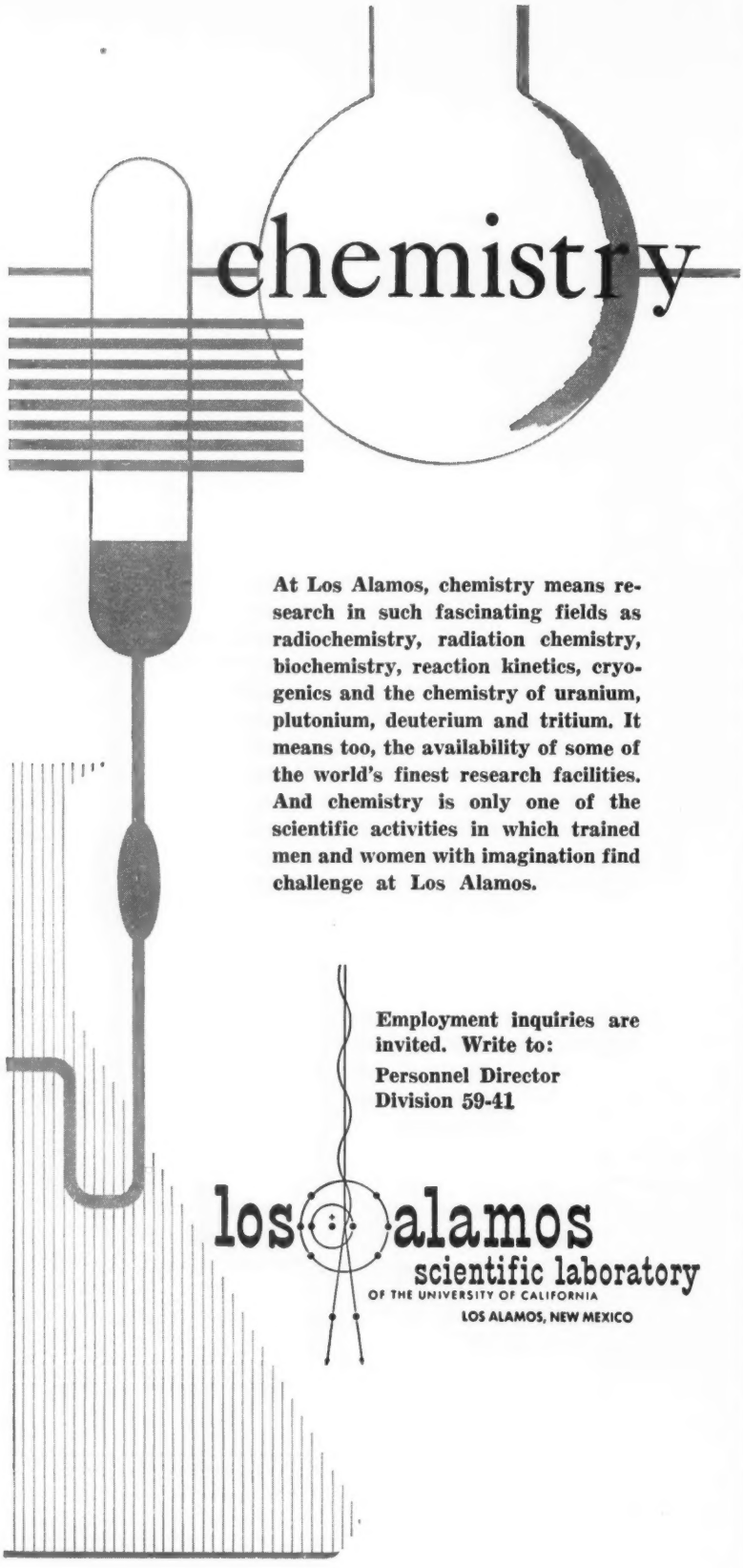

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Designing Payloads

(CONTINUED FROM PAGE 25)

vertical sounding rocket for star measurements. It employs the same equatorial scanning technique as the lunar scanner with one exception. Since the vertical rocket will not significantly change its position with respect to the stars during its ascent, a mechanism for processing the system in a uniform and somewhat predictable manner is included.

Precession is to be accomplished by means of a fixed magnet, which, as it moves through the earth's magnetic field, imparts torque to the system and gradually tips the payload. This gives progressive strip scans of the celestial hemisphere. The gyroscopic stability of a frictionless spinning mass in space and the interaction of a magnet with the earth's magnetic field both assist in simplifying the instrumentation by eliminating moving parts and need for a torquing mechanism.

There are plans to carry this development further if preliminary results justify detailed exploration of some particular portions of the sky. The second drawing on page 25 illustrates the design of a controllable spinning telescope. In this design, the optical system has its axis coincident with the spin axis. The image of the total field of view at the focal plane is sampled along a radial line from the center of the image to its outer edge at a rate slow compared to the spin rate. Hence, the small sampling field of view describes an outward moving spiral which covers the entire field of view in a number of revolutions equal to the line resolution of the system.

Ground Control Test

Initially, it is planned to test this device without attempting to vary the spin (or telescope) axis. The data, then, will give detailed information on only a small circular portion of the sky—a portion equal to the total field of view. Upon completion of that phase, an attempt will be made to include a precession system that can be controlled from the ground. The precession motor under design uses a high pressure gas emitted from a nozzle parallel to, but offset from, the spin axis. To achieve precession, small short bursts of thrust are delivered at the right time in each spin cycle to cause precession in the desired direction.

Such a ground-controlled precessible telescope will permit selection and observation of regions of interest for extended periods. For example,

incorporation of a small spectrometer into the system will permit the gathering of stellar spectral information in the ultraviolet.

Achievement of this goal is not expected to be easy. Nor will the ultimate system be extremely simple, although the number of moving mechanical components will be extremely small. Development of the system will be based upon a succession of small payloads in accordance with the principles we have described earlier. It is clear that the program will require several firings with different payload designs to develop the ultimate "pointable" extra-atmospheric scanner. To accomplish this without enormous funding requires small payloads that can be boosted with small existing rocket motors.

Our two payload-design principles are to a large extent complementary. For example, in the vertical equatorial scanner, simplification and miniaturization are achieved by using the magnet to generate precession. At the same time, since the strength of permanent magnets is limited, the weight of the payload must be kept low for the magnet to produce the required tilting rate. Similarly, if one attempts to utilize solar cells for electrical power, the advantages decrease if external structures are required to increase the area available to solar cells.

If experiment designers are to produce payloads of simplicity and reliability by using the space environment, care must be exercised to optimize component packaging. While it is not possible to reduce packaging techniques to general principles, one means of simplifying packages is to allow components to serve dual functions.

An example of the type of package developed at NOTS may be seen in the photo at the bottom of page 25, as well as those drawings discussed. This photo shows the 50-watts crystal-stabilized transmitter for the 8-lb scanning system carried in the AF Pioneer launched Oct. 11, 1958, in an attempt to orbit the moon.

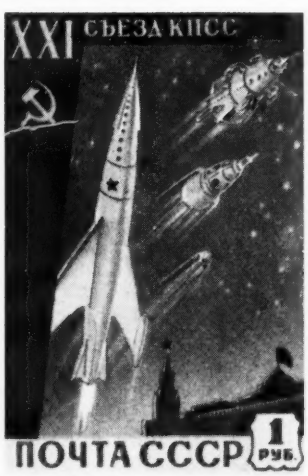
Prepared at NOTS, this system was designed to scan the surface of the moon from horizon to horizon, gradually covering its whole surface. The picture was to have been transmitted 240,000 miles to a special AF receiving station in the Hawaiian Islands, recorded on magnetic tape, and regenerated into a television-like picture.

The system was composed of eight major parts. A detector and telescope looked out through a hole in the side of the payload. The detector fed a scanning signal to an amplifier. From the amplifier the signal fed through a modulator to the crystal-stabilized transmitter. A power switch, a 1-lb converter, and a 108-mc oscillator weighing 2 oz connect to the transmitter. Power for the system was supplied by a battery pack, weighing almost 5 lb, that had enough energy for 3 hr of continuous operation.

The output coil of the transmitter is wrapped around and bonded to the tube envelope. This eliminates the use of an extra fixture serving only to fasten and support the coil. The use of the antenna as an aerodynamic spike on the star-scanning payload also illustrates how dual functions can be achieved.

Such instruments as these promise to bring us both new and more precise knowledge of the regions beyond the earth's atmosphere. They constitute a major contribution to the national space program by giving a maximum of select scientific data in terms of dollars investment for space vehicles.

Sputnik Stamp



This stamp, issued by Russia to commemorate the 21st Communist Party Congress in Moscow, pictures the first three Sputniks and what appears to be a large three-stage rocket, possibly an idealized version of the Sputnik launching vehicle.

Republic, Grumman, Fairchild Form Space Projects Team

Three Long Island companies—Grumman Aircraft Engineering, Republic Aviation, and Fairchild Engine and Airplane—announced recently that they would pool facilities and talents to work on missile and space programs.

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Progress in Space Technology

How General Electric delivered first U.S. operational re-entry vehicle

General Electric Missile and Space Vehicle Department helped USAF Ballistic Missile Division solve re-entry problem . . . speed Thor operational readiness.

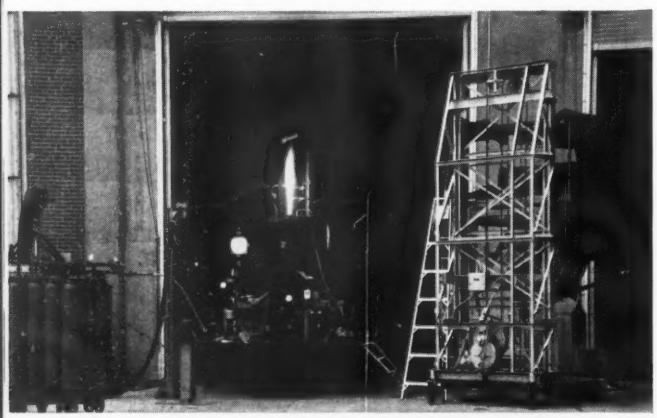
CAPABILITIES DEVELOPED RAPIDLY—Early in 1955, General Electric's Missile and Space Vehicle Department began research and development work on the vitally important re-entry phase of the USAF ballistic missile program. A skilled core of G-E scientists with hypersonic and missile technology experience were pulled together from all parts of the Company. Special research tools were developed and put into use at MSVD's new Aerosciences Laboratory. Advanced shock tunnels reproduced high Mach air flows—10,000 to 25,000° F plasma jets simulated extreme re-entry heats. With such new tools, G.E. gained vital knowledge of the re-entry environment.

FLIGHT TEST PROVED DESIGN—MSVD engineers were convinced that the heat-sink type re-entry vehicle offered the best approach to providing the Air Force with an *operational* weapon at the *earliest possible date.* Later, flight tests proved the soundness of the General Electric approach. On schedule, only 30 months after research and development began, the Air Force launched the free world's first operational re-entry vehicle on Thor.

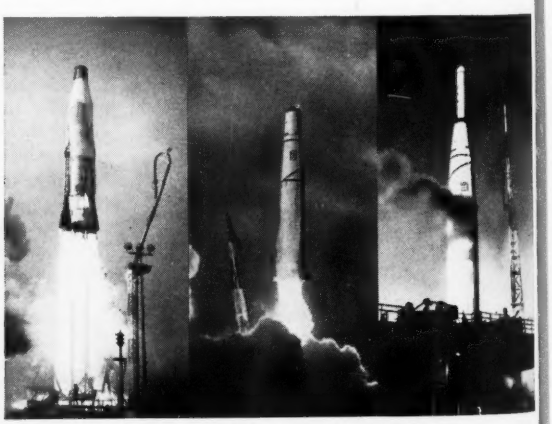
Missile and Space Vehicle Department engineers were also able to make important advances on other fronts associated with the re-entry challenge. Complex re-entry vehicle ground support equipment was developed; rocket-sled tests aided in solving fuzing problems. It was also necessary to build one of the country's most advanced data processing and computation centers to keep pace with the need for rapid processing of Air Force re-entry data.

PRODUCTION ON SCHEDULE—To prepare for Thor missile re-entry vehicle production, General Electric acquired and developed special manufacturing facilities and techniques. Proof of the smooth, rapid transition from research and development to production is the fact that Thor re-entry vehicles have passed *all operational qualification tests* and are being delivered on schedule to the Air Force for air lift to key overseas bases.

ADVANCED NOSE CONE DEVELOPMENT—Meanwhile, development continues on more advanced re-entry vehicles. Last year, one such G-E re-entry vehicle, the Thor-Able, successfully re-entered at an ICBM range of over 5500 nautical miles. With more than four years of success as an associate contractor on the Atlas, Thor and other programs, *General Electric is the leader in re-entry vehicle development and production experience.* This proven competence will continue to grow as MSVD applies its re-entry experience to the expanding list of new missile and space projects. *Missile and Space Vehicle Department of the Defense Electronics Division.* 224-50



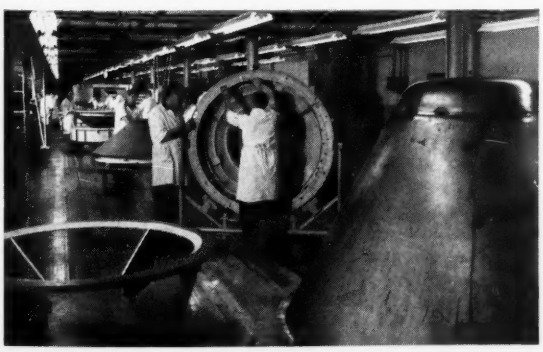
NATION'S LARGEST PLASMA JET PLAYS KEY ROLE in providing information leading to the solution of the re-entry problem. Plasma Air Arc and many other re-entry research tools were developed by MSVD Aerosciences Laboratory scientists.



OVER 1½ YEARS OF FLIGHT TEST EXPERIENCE on Atlas, Thor and Thor-Able missiles has been gained by General Electric covering both heat-sink and ablating types of re-entry vehicles for the USAF. These three ballistic missiles are pictured above.

A GENERAL ELECTRIC RE-ENTRY VEHICLE is mated to a Thor Missile in the first SAC operational test flight exercise from Vandenberg Air Force Base.

Official U.S. Air Force photograph



RE-ENTRY VEHICLES ARE ASSEMBLED at MSVD facilities in Burlington, Vt., for both THOR and ATLAS ballistic missiles.

These Free Booklets Describe MSVD Ballistic Missile Re-entry Vehicle Work.

Indicate the brochures that you would like to have and send to: Section B224-50, General Electric Co., Schenectady, New York.

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Design and Fabrication of Re-entry Vehicles	**GER-1583**
Heat Protection of Re-entry Vehicles	**GER-1582**

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People in the news

APPOINTMENTS

NASA has appointed **Ira H. Abbott** deputy director of aeronautical and space research and **Edmond C. Buckley,** former chief of the Instrument Div., Langley Research Center, assistant director, Space Flight Operations. Abbott will continue as assistant director of research, Aerodynamics and Flight Mechanics. **Abraham Hertzberg,** assistant head of the Aerodynamic Research Dept. at Cornell Aeronautical Lab, has been made a member of the Research Advisory Committee on Fluid Mechanics; **W. M. Duke,** vice-president and director of Space Technology Labs R&D Div., of the committee on structural loads; and **W. T. Russell,** director of STL's Electromechanical Lab, of the committee on control, guidance, and navigation. **Alfred M. Nelson** has joined NASA as an aeronautical research scientist.

Elliot Mitchell, chief of NASA's Solid Rocket Development Program, has been appointed to the advisory board of the U.S. Naval Propellant Plant, Indian Head, Md.

George D. Sands, former chief of the Nuclear Branch, Army Transportation Research and Engineering Command, Ft. Eustis, Va., has been named to the new post of director of scientific requirements at Martin Co. **Harold W. Berger,** former chief of program analysis and control, Systems Test Dept., Denver Div., becomes director of the division's new Field Service and Support Div.

Thompson Ramo Wooldridge has appointed **Arch T. Colwell,** formerly vice-president, Thompson Products, Inc., to the new post of vice-president of engineering, research and development. **T. R. Thoren** becomes assistant to **Ralph P. Johnson,** vice-president and general manager of Ramo-Wooldridge Div.; **T. C. Noon,** engineering manager of TRW's Tapco Group; and **W. A. Johnson,** manager of metallurgy and chemistry, Tapco Group.

Walter Kleczek, former manager of Vanguard engineering, GE, becomes project manager for development of a liquid propellant engine to power the second stage of the Vega space vehicle.

George C. Szego, former manager, GE Space Propulsion Operation, has joined Space Technology Labs, and will devote himself to research on advanced energy sources and propulsion systems in the Systems Projects Office. **Walter B. Brewer,** has been appointed associate manager, Airborne Systems and Test Dept., Atlas Program Office, while **Adolph K. Thiel,** former director, Thor Program Office, has been appointed program director for space missions.

Philip S. Fogg, president and board chairman of Consolidated Electrodynamics Corp., and **Kennett W. Patrick,** CEC vice-president, have been elected board chairman and president, respectively, of the new Consolidated Systems Corp., formerly the Systems Div. Other CSC officers are: **Harry E. Burke Jr.,** vice-president and general manager; **Franklin H. Donnell,** financial vice-president; **Victor J. Pollock,** secretary; and **Wilford R. Penny,** treasurer and assistant secretary. **John J. McDonald** has been named director of engineering and **Linden G. Criddle,** director of manufacturing.

Named as manager and chief engineer, respectively, of the following CES departments are **C. Kenneth Hines** and **Frank C. Bumb,** Process Systems; **Bliss M. Bushman** and **Alan D. Marston,** Data Processing Systems; **John D. Gum** and **William D. Schultz,** Instrumentation Systems; and **James T. Sharpsteen** and **Wayne J. Whistler,** Electromechanical Systems. **John C. Alrich** becomes manager of Industrial Systems and **Frank E. Chase,** manager of Field Engineering.

Kenneth S. Teel has been named to head the newly formed human factors engineering group in the Advanced Engineering Dept. of North American's Autonetics Div. **Arnold Miller** and **Josef Kasper** have joined the department's research staff.

E. M. Baldwin, former general manager of Fairchild Semiconductor Corp., has been named vice-president and general manager of a newly formed Rheem subsidiary for R&D and production of semiconductors and semiconductor devices.

Herbert R. J. Grosch, a past president of ARS, has been appointed manager of space programs for IBM's Military Products Div., and will be in charge of the Vanguard Center in Washington, D.C.

Hyman Stein, project manager on space projects for Republic Aviation, has been appointed consultant to the Aero and Space Vehicles Panel of the AF Scientific Advisory Board.

Ralph L. Bayless, former chief engineer of Convair's San Diego Div., has been appointed Convair director of engineering; **William W. Fox,** former assistant chief engineer of the division, succeeds Bayless, while **Richard P. White,** former chief technical engineer, replaces Fox. **Harry T. Dillon,** project staff engineer at the Pomona Div. becomes manager of a new field office at Huntsville, Ala.

Lt. Gen. James M. Gavin (Army-Ret.), former chief of Army R&D and recently in charge of Arthur D. Little's regional offices and management services division, has been elected executive vice-president of the company.

Wendell L. Haubein and **Thomas J. Creley** join Propellex Chemical Div., Chromalloy Corp., as project engineers.

Robert E. Roberson, formerly chief of astronautical sciences at NAA Autonetics Div., has been appointed director of advanced space guidance for Systems Corp. of America.

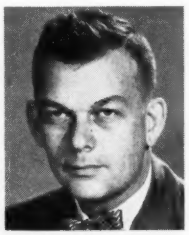
Charles W. Perelle, president of American Bosch Arma, has been re-

Berger

Szego

Thiel

Patrick



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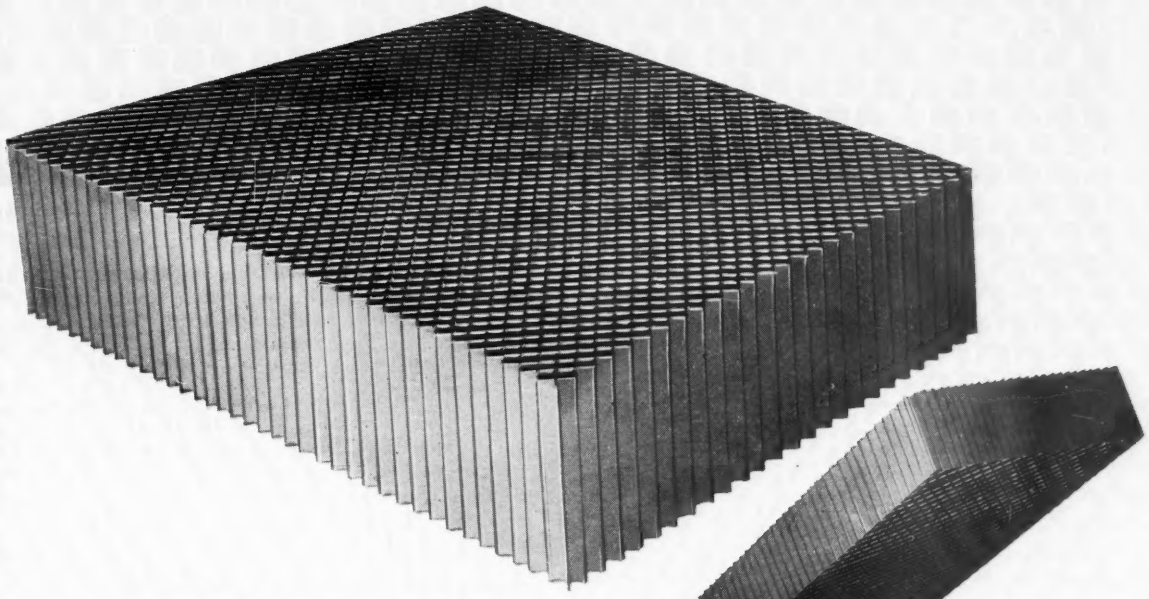
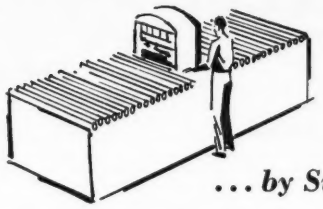
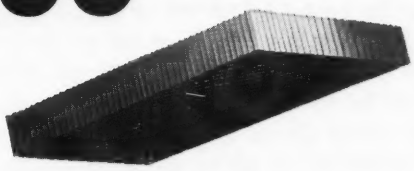


PROGRESS





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Kenneth H. Jacobs, former director, Engineering Div., Chicago Midway Labs, has been appointed director of engineering at Grand Central Rocket Co. **Emmitt Graham II,** former project manager on the Army Dart program, has been promoted to manager of a new company office at Huntsville, Ala.

John J. Carpenter has been named a vice-president of the Bulova R&D Labs., and will continue as general manager of the parent company's electronics and camera divisions.

Walter R. Kuzmin, former supervisor of reliability engineering at Minneapolis-Honeywell Regulator Co., has joined Packard-Bell Electronics as manager of reliability engineering, Technical Products Div.

Kenneth R. Bragg has been appointed chief systems engineer at Parker Aircraft Co.

Robert S. Caruthers, former deputy director of research and engineering, ITT, has been elected vice-president and technical director of ITT Labs. **Andre G. Clavier** has been appointed scientific adviser to Labs president, Henri Busignies.

The Advanced Projects Organization of Chrysler Corp. Defense Group has promoted **James S. Smith Jr.,** former chief project engineer, Chrysler Missile Div., to executive engineer; **Charles W. Williams,** to director of manufacturing operations; **John M. Martin,** former manager, Jupiter engineering project staff, Missile Div., to director of plans and programs; and **Robert C. Terbeck,** former assistant chief engineer for field support, to director of field operations.

David A. Conrad has joined Hughes Aircraft Co. as head of the analysis group of the engineering laboratory's servomechanics section. **Blanchard Cain,** former manager of new programs at American Machine and Foundry, will head the lab's mechanical section. **John K. Matsushino** and **Edward Sax** have joined the technical staff.

George B. Rathmann, who recently became project manager for Minnesota Mining and Mfg.'s ARPA contract, has named **William S. Friedlander** supervisor for evaluations research; **B. F. Landrum** supervisor of synthesis research, and **James W. Millin** business coordinator.

Homer R. Oldfield Jr. has been made division chief of Raytheon's new separate light and heavy units in its Government Equipment Div. Reporting to Oldfield will be newly appointed assistant division managers **Glenn R. Lord** and **W. Rogers Hamel** of light and heavy equipment, respectively. **Robert W. Miller** becomes manager of systems and procedures for the division. Named to light subdivision posts are **Robert E. Sonnekson,** to manufacturing manager, and **Homer C. Knauss,** to assistant director of equipment engineering.

H. V. Perryman has been promoted to the newly created post of corporate director of industrial relations at Lear, Inc.

N. E. Halaby, former vice-president of finance and administration, Servomechanisms, Inc., has been appointed to the new post of executive vice-president.

Paul S. Goodwin has joined Ling Electronics as special staff assistant to vice-president and chief engineer James A. Ross, with duties as senior project engineer for underwater sound systems. Goodwin had been engineering division manager and manager of the analytical systems division, Applied Research Labs.

Donald H. Menzel, has been appointed vice-president of Geophysics Corp. of America, and will lead the newly formed Astronomics Div.

John A. Thoerle has been named field liaison engineer at McCormick Selph Associates.

Ralph P. Morgan Jr., has been appointed project manager for Aeronutronic System's contract in connection with the Air Force's ICBM program.

Stephen B. Elggren and **Terence M. Nolan** have been elected assistant vice-presidents of Bell Aircraft Corp.'s Niagara Frontier Div.

Joseph Statsinger, former assistant chief engineer in charge of missile guidance at American Bosch Arma, has joined Servo Corp. of America as director of engineering.

Carlos G. Wood, former chief engineer, Douglas Aircraft Long Beach Div., has been appointed to the newly created post of director of advanced engineering planning. **Charles S. Glasgow,** assistant chief engineer, succeeds Wood. New appointments in the engineering department are **F. W. Wolcott,** former chief advanced design engineer, to assistant to the chief engineer, advanced engineering planning; **R. E. Bates,** former assistant to Wolcott, to chief of advanced design section; and **T. P. Browne,** former group leader, preliminary design and advanced systems analysis, to assistant chief, advanced design.

Jim Ricketts, director of manufacturing for systems support, Nortronics, has been named Army Rocket and Guided Missile Agency (ARGMA) project director.

Mervin J. Kelly former board chairman of Bell Telephone Labs., will serve as a consultant for Bausch and Lomb Optical Co. He is currently a board member of BLO.

Manson H. Hayes, former technical director of the Palo Alto Lab, Link Aviation, has been named vice-president in charge of research, development, and engineering activities.

HONORS

Dean R. Chapman, aeronautical research scientist at the NASA Ames Research Center, Moffett Field, Calif., has been awarded a Rockefeller Public Service Award for 1959–60, and will concentrate on the study of astronomy, astrophysics, electromagnetic theory and relativity at Cambridge Univ., England. The award is designed to give special recognition for outstanding public service as well as to establish incentives for the advancement of federal civilian personnel. Dr. Chapman is currently charged with the origination and direction of theoretical and experimental research pro-

grams aimed at understanding basic aerodynamic and heat transfer phenomena associated with supersonic flight and atmosphere re-entry.

Robert H. Boden, program engineer on the ion engine research activity at Rocketdyne has been awarded the Manly Memorial Medal for his paper "The Ion Rocket Engine," presented during the 1958 SAE National Aeronautic meeting.

Hermann I. Schlesinger, professor at the Univ. of Chicago and a leader in research on high energy compounds for jet and rocket fuels, received the Priestley Medal at the 135th national meeting of the American Chemical Society.

George Sutton, Ex-ARS Pres., Delivers Minta Martin Lecture

George P. Sutton, ARS past-president and Jerome Clarke Hunsaker Professor of Aeronautical Engineering at MIT, presented the fourth annual Minta Martin Lecture on the subject of "Rocket Propulsion Systems for Space Flight" at MIT, last March. Minta Martin Lectures are given at aeronautical engineering centers throughout the country in cooperation with the Institute of the Aeronautical Sciences.

Regarding interplanetary flight, Prof. Sutton said that present chemical rocket engines are adequate for flights to Venus and Mars, but for deep penetration of space a nuclear or electric type of rocket will be essential. Though "all the various systems seem to offer some growth potential in improved performance, efficiency, lower engine weights, or thrust, the real need seems to be for a simple lightweight high energy source to replace an airborne nuclear reactor," he noted.

Ultimately, he believes, "standard interplanetary stages will be designed and modified slightly for different missions. For the same basic weight in an earth orbit, the electrical systems will be capable of carrying the most payload (chemical systems will carry the least) to a given interplanetary target. For the long range outlook, they (ion and magneto plasma propulsion) are the most attractive in performance."

Space laboratories will be essential for development and testing of interplanetary rocket engines, he said. They probably will be special controlled satellites that will permit operation of engines in the proper environment.

New availability in skin sizes, cores and adhesive materials now make wider range of honeycomb sandwich combinations possible for the electronics engineer.

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BOEING

960-mc Lunar Transmitter

(CONTINUED FROM PAGE 31)

Varactor tripler, which has an output of 15–20 mw at 960 mc. The required 960-mc harmonic component is extracted from the Varactor output with a high-Q filter in the form of a quarter-wave resonant cavity.

The vacuum tube amplifier, shown disassembled on page 30, is operated in a grounded grid configuration. The gain is 12 db, and the plate efficiency as a Class AB amplifier is 30 per cent. A comparison of the efficiency of the three sub-units is made in the first table on page 31, which also includes the over-all efficiency of the transmitter.

The cases of all three units are fabricated from magnesium and are silverplated for RF conductivity. The operating time depends on the size and type of battery used; the time given in the table of transmitter characteristics is based on currently available mercury cells.

This transmitter demonstrates the possibilities of obtaining extreme ranges in outer space using recently developed communications techniques combined with the latest advances in solid-state and component development. There is little indication that transistor developments in the near future will change the general concept of tube-plus-transistor circuitry for the generation of medium power at UHF.

Suggested Additional Reading

The Exploration of Space by Radio, by H. R. Brown and A. C. B. Lovell, Chapman and Hall, Ltd., 1957.

Modulation Theory, by H. S. Black, Van Nostrand Co., Inc., New York, 1953.

Principles of Transistor Circuits, by R. F. Shea, John Wiley and Sons, New York, 1953.

Miniature Movies

(CONTINUED FROM PAGE 28)

kind we have just outlined was part of the Pioneer II payload, and similar systems are being constructed for future space vehicles. The optical and electronic portions of these systems can be described briefly at this time.

The photo on the left on page 28 shows the optical unit for a future probe. The photosensing device is a phototransistor, mounted behind a field stop with a pinhole aperture. Light from the planet is focused on the field stop by a concave spherical mirror. The mirror, phototransistor, and aperture assemblies ride in a short cylinder. The pinhole diameter is chosen to yield an optical beamwidth of 0.5 deg. A cable carries the video signal to the electronics unit.

Care must be exercised in determining the output voltage for the expected surface brightness of the image. The spectrum of the reflected light from the planet and the response of the phototransistor must be taken into account. The phototransistor has its greatest response in the near-infrared, whereas the light reflected from astronomical bodies, such as the moon or Venus, has a spectrum similar to solar radiation, peaking in the visible region. Proper calibration of the optical unit requires a laboratory source which, for a brightness equal to that of the planet, yields a sensor output voltage that can be related to the output obtained from the planet's reflected light.

The photo on the right on page 28 shows the electronic unit with the cover removed. Transistors and printed circuit construction are used throughout.

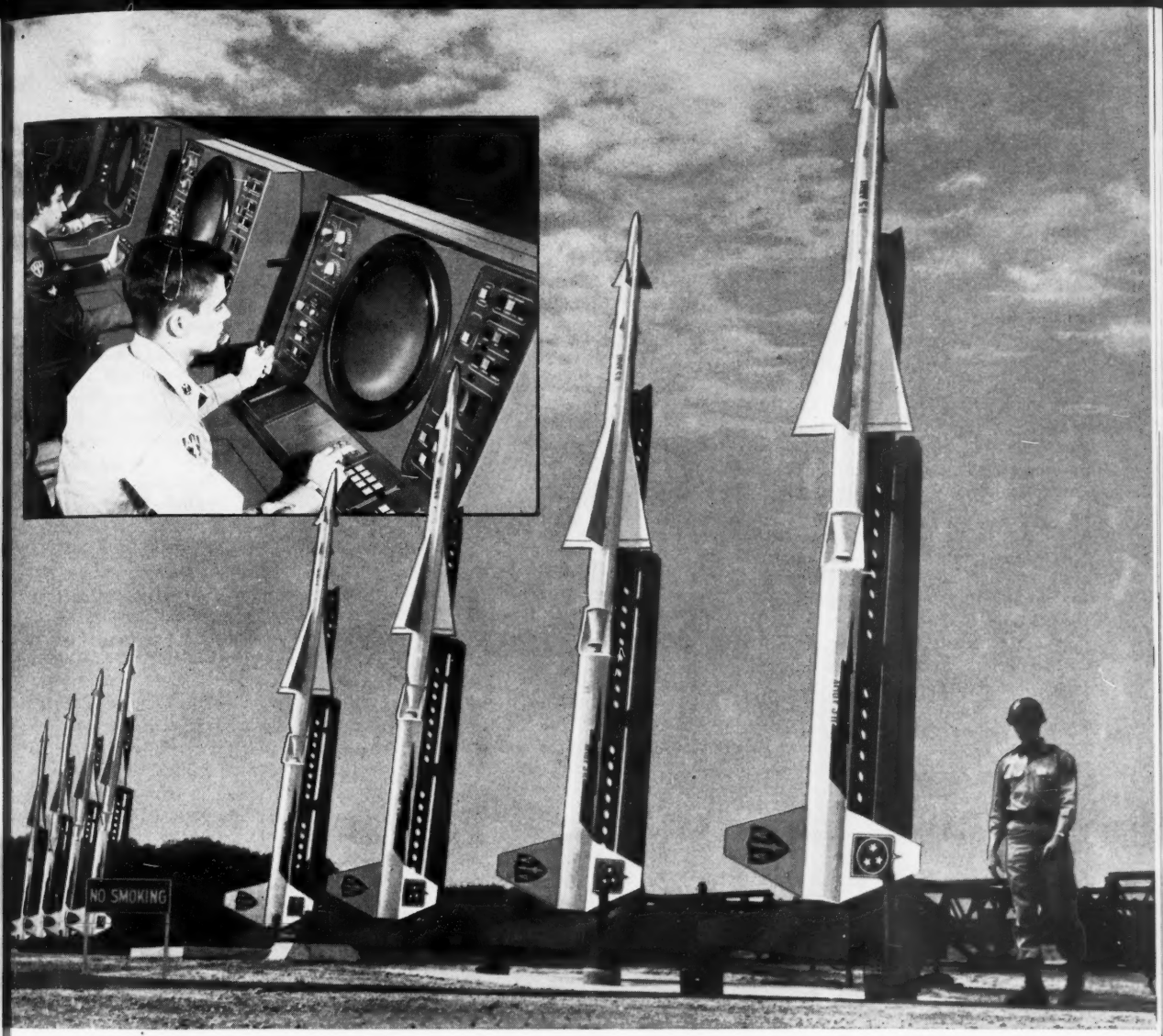
A block diagram of this unit is shown on page 28. When the optical beam crosses the limb of the planet, the phototransistor voltage rise is sensed by a trigger which starts a clock. The clock pulses are counted in Scaler A. This count is compared with a fixed count on Scaler B. When agreement is obtained, the clock is shut off and the video waveform sampled. At the same time, one count is added to the fixed count on Scaler B so that, for the next spin revolution, one more clock pulse will be required before sampling.

Each video sample is held for one spin revolution until the next video sample is obtained. Thus a full spin period is used for the transmission of a single sample. This method achieves a low bandwidth and high duty factor.

Choosing a Sampler

The sampler may be a conventional electronic gate or an analog-to-digital converter. The latter has an advantage in that outputs in digital form are available for transmission, as well as a quantized analog signal derived by mixing the binary outputs.

The complete image system, including both electronic and optical units, weighs 1.75 lb and requires about 200 mw of primary power at 6 volts. Temperature compensation is provided where necessary to permit operation at temperatures as low as −20 F. Outside surfaces are goldplated to reduce short-term fluctuations of tem-



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perature by increasing the thermal time constant.

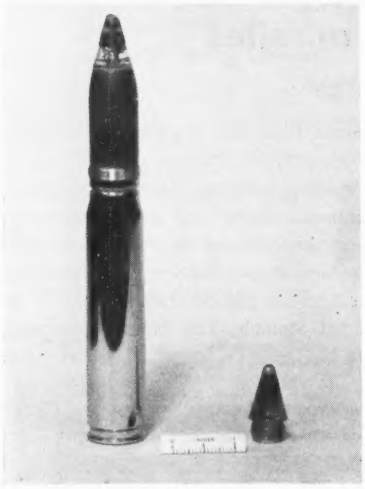
The complete image system need not be duplicated if several images of the same subject are desired in different spectrum regions. Only a video amplifier, sampler, and hold circuit must be provided for each sensor used. A separate telemetry channel is required for each output unless the signals are time-shared.

A multiple system of this sort might be employed to obtain simultaneous images of a planet in the infrared, visible, and ultraviolet regions of the spectrum. For a planet such as Mars, three sensors, sensitive to red, green, and blue regions of the visible spectrum, would make it possible to take a color picture.

For a multichannel system, the bandwidth required of the telemetry system is increased in proportion to the number of spectrum regions observed.

Another extension of the present system would allow its use for mapping incoming radiation over the entire sky. Of particular interest would be the Lyman-α radiation distribution, which cannot be obtained from earth because of the atmospheric attenuation of ultraviolet. For use in the ultraviolet, the optical unit would require a different sensor and elimination of reflectors and refractors is indicated. Slow scanning in the plane containing the spin axis would also be required. The electronic system would need only slight modification. For example, some means for triggering by the sun would be necessary.

Miniature Transmitter



A radio transmitter (right) the size of a pencil eraser has been developed for use in ballistic studies by Diamond Ordnance Fuze Laboratories.

Fellow Engineers and Scientists:

My company has asked me to tell you of the unusual opportunities in operations research at System Development Corporation. These range from positions for engineers and scientists who would like to develop their skills working in a team under an experienced leader to opportunities for those who are looking for positions of leadership. I hope that the following account of our work will lead you to inquire for further information.

Briefly, SDC's business is automated decision-making systems. More fully, we develop large scale, computer-based information processing systems in which the computer is used as an on-line, centralized control element for a system operating in real-time. At this stage of the art these systems are semi-automatic, the man-machine type in which man shares the repetitive control function with the computer. Our work is concept-oriented, rather than hardware-oriented, and deals with problems of over-all system design, data processing development, and man-machine system training.

The most fully developed large-scale semi-automatic system is the SAGE (Semi-Automatic Ground Environment) Air Defense System. We have a major responsibility in the development of SAGE. Our experience and unique team skills have led to diversification of our activities; we now have important contracts for other major military and government systems vital to our country. The demand for our services is reflected in our growth from 70 to more than 2,700 employees since 1955, and the intriguing possibilities of automated decision-making are only beginning to be realized.

In this brief message, I can only suggest the variety of operations research problems at SDC. Perhaps the most important point is that this variety is limited only by the imagination and initiative of our scientists.

Some examples of areas of work are: (1) allocation of decision-making functions between man and machine for optimal system performance; (2) measures of system capacity and system performance; (3) exploration and evaluation of design changes by operational gaming; (4) quality control and testing of operational computer programs; (5) allocation of computer capacity among several system functions; (6) scheduling and costing of production of operational computer programs; (7) optimal assignment of mixed weapons to targets.

SDC recognizes the importance of a well planned research program for the vitality and future of the company, and we are carefully organized to carry out such a program. The following are some areas our operations research people are involved in: (1) simulation and operational gaming techniques in problems of control systems; (2) information retrieval and theory of information processing; (3) medical data processing; (4) universal language for computer programming; (5) logistics. We have unusual facilities for research at SDC—these include one of the largest computer facilities in the world and outstanding simulation laboratories.

We have given considerable thought to organizing the activities at SDC to provide for professional development and self-expression. Operations research professionals are carefully assigned so that their individual talents are matched with company needs. These assignments are reviewed regularly to make sure that developing talents are directed into new company opportunities. We regard the publication of research articles and participation in professional societies as activities important to the company. We encourage new ideas and provide the time and means to explore them.

SDC is one of the leaders in a field which will have a remarkable technological and scientific development. It is a new and vigorous company with a bright future. I encourage you to join us.

Please write Mr. R. W. Frost at the address below if you wish to pursue this invitation.

William Lowe

11-105A

SDC

S

William Karush
Assistant Director for Research
Operations and Management Research
System Development Corporation

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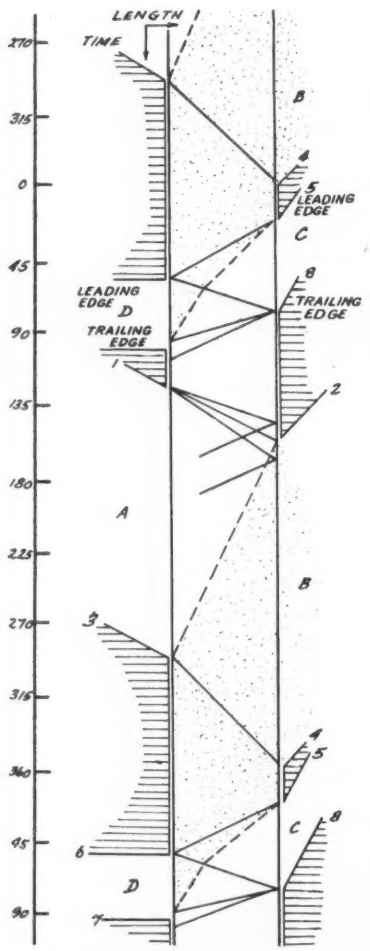
From the patent office

By George F. McLaughlin

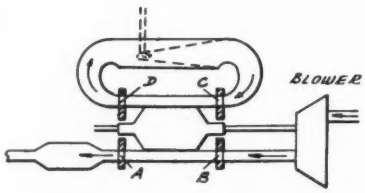
Aerodynamic Wave Machine

Principles of a turbine-compressor operating on nonsteady flow phenomenon are described in a patent assigned to ITE Circuit Breaker Co. The invention relates to a jet engine which produces not only kinetic energy, but also transforms energy into shaft power for various purposes, such as driving a ducted fan or propeller. The apparatus perfoms the conventional thermodynamic cycle of a jet engine and a combination of compressors, combustion chambers, and turbines; the turbine rotor performs part of the air compression by wave interaction.

The device is comprised of a rotor



Representation of shaft power extraction laid out in one plane showing compression and expansion waves and the interface between hot and cold gas.



Cross-sectional view of aerodynamic wave machine.

with channels positioned around the outer periphery. The curved portions of the rotor blades act as a turbine, and also provide the phase angle between the compression and expansion waves in each channel. One of the stator plates contains the cold-air pickup port (D) and the hot pickup port (A). Another stator contains the hot-gas intake port (C) and cold intake port (B). Air compressed in the compressor is supplied to port B through a duct. The entire compressed cold-air mass flow from port D is supplied to the combustion chamber and mixed with the fuel injected. Following combustion, hot gas is supplied to intake C. The machine exhausts through port A to the exhaust duct, and thence to the jet nozzle to deliver propulsive thrust.

The diagram below left shows the rotor laid out in one plane, and illustrates conditions existing in all portions of the rotor, at any location and instant assigned to the leading edges and trailing edges of ports A, B, C, and D. As the rotor cells move successively past the ports parts, various compression and expansion waves (shown by solid lines) are created, with interfaces between different gases. As a result of the compression waves, the gases and their interfaces (shown by dashed lines) flow across the channel.

At the left of the diagram, indicia are marked as angular location at the stator plates in direction of rotor rotation. Assuming that the cycle starts at 110 deg, the gas within the cell will be stationary, and both its left and right ends will be closed off by the stator plates.

Patent No. 2,867,981. Aerodynamic wave machine functioning as a compressor and turbine. Max Berchtold, Paoli, Pa.

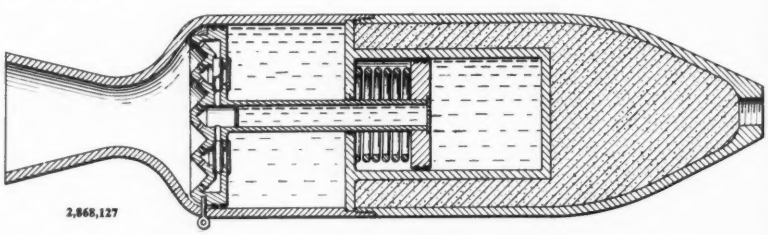
Controlled Liquid Propellant Feed System

Four important advantages are claimed for a newly patented automatically controlled liquid propellant feed system for rocket motors: (1) The system adapts to large and small missiles; (2) control of flow at ignition is achieved by a simple mechanical system; (3) combustion instability generated from the oscillations of fuel column between fuel and oxidizer is eliminated; and (4) flight stability is increased, since liquid surface effects are eliminated.

The system operates as follows: A starter pin releases a compressed spring, which pressures the fuel and oxidizer tanks. This pressure opens burst diaphrams in the tanks, allowing hypergolic fuel and oxidizer to flow through separate nozzles. Combustion of these propellants develops pressure on a piston that forces nonhypergolic fuel and oxidizer through nozzles after the hypergolic fuel supply is exhausted. Piston movement continues to supply fuel and oxidizer to the combustion chamber, and to enlarge the chamber until the tanks are empty.

Although hypergolic propellants are preferred for initiating combustion, ignition can be obtained by a spark plug, powder charge, catalyst, or other means.

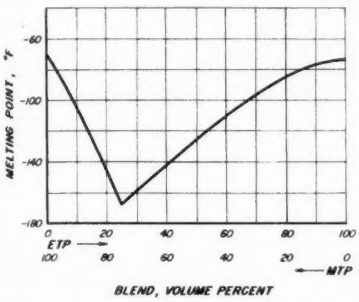
Patent No. 2,868,127. Homer M. Fox, Bartlesville, Okla., assignor to Phillips Petroleum Co.



Schematic view in cross section of automatically controlled feed system.

Liquid Rocket Fuel With Low Freezing Point

A missile usually is exposed to the extreme cold of high altitudes long enough to attain atmospheric temperature. This temperature may be low enough to freeze liquid fuel in the missile. The invention advances a low-freezing-point fuel.



Melting points of blends of triethyl trithiophosphite and trimethyl trithiophosphite.

This fuel consists of a mixture of between 10 and 65 per cent by volume of triethyl trithiophosphite (ETP) and between 90 and 35 per cent (i.e., the remainder) of trimethyl trithiophosphite (MTP). It has a melting point below −100 F, as described by the diagram. The fuel is hypergolic with some oxidizers.

Method of Rocket Propulsion (2,857,737). *Don R. Carmody, Crete, and Alex Zletz, Park Forest, Ill., assignors to Standard Oil Co. of Indiana.*

Spaceship Air Conditioning

In the air conditioning of spaceships, and aircraft designed to fly at extreme altitudes, it is necessary to supply oxygen to the cabin, remove heat from the cabin, and circulate atmosphere within the cabin. At low or nearly zero gravity, natural convection will not circulate the air, and portions of the cabin could become so highly contaminated, due to stagnation, that they would not sustain life.

Suggested as a solution to this problem is a device incorporating a vortex tube to draw air from the cabin, mix it with incoming gaseous oxygen, reintroduce it into the cabin. In addition, the vortex tube cools the cabin atmosphere. The function of the vortex tube is indicated in the accompanying diagram of an air-conditioning system utilizing a supply of liquid oxygen as refrigerant.

The vortex tube is of seamless tubing with a smooth finish. The tap is enclosed by a flat plate with an opening at its center, to which a conduit is connected. Projecting through the wall of the tube, adjacent the top plate, is an inlet nozzle that introduces oxygen gas tangential to the inner surface of the tube. The nozzle passes through a chamber surrounding the outside of the tube.

Mounted in the conduit containing the pressurized oxygen is a flow control valve actuated by a sensing element in the cabin. The element is connected to the valve by a lead which senses the oxygen level, temperature level, pressure level or any combination of these levels, and controls the flow of pressurized fluid to the nozzle.

The supply of liquid oxygen is carried in a double wall pressure vessel. Even when such a vessel is used, sufficient heat will be transmitted through the walls to convert part of the liquid oxygen to a gas, and a valve must relieve pressure in the vessel.

The bottom of the vessel is connected to a heat exchanger surrounding the vortex tube. A baffle causes liquid oxygen to flow in a helical path around the outside of the vortex tube, thus cooling the air it carries.

Except for the valves, the device has no moving parts. It will be relatively small and light in weight.

Air Conditioning System for Spaceships. Patent No. 2,873,582. Frederick H. Green, Palos Verdes Estates, Calif., assignor to The Garrett Corp., Los Angeles, Calif.

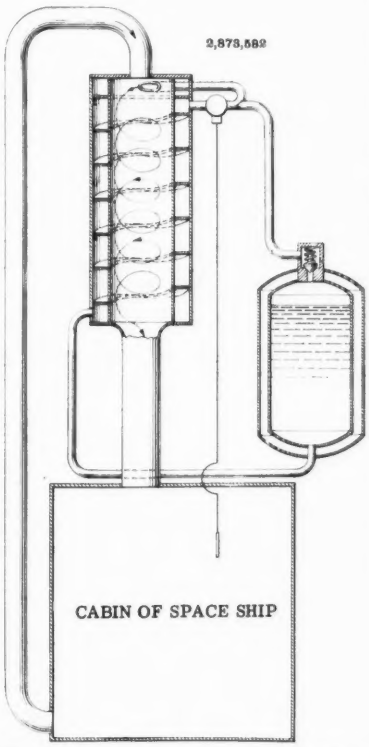


Diagram of Air Conditioning System

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Frequency Standard

(CONTINUED FROM PAGE 41)

to stacking and potting. The operation of these units is also tested on the jig in an environmental chamber at hot and cold temperatures. The jig also serves in checking high and low voltage stability and lock-in voltage ranges of the binary dividers. Any malfunctions can be quickly traced to a wafer unit, and the unit readily replaced.

In stacking the system, as shown in the next picture in the series, the support rods around the periphery of the wafer serve to conduct power from the battery supply (28 volt DC) and bias voltage to each wafer and also supply the ground connections. One coupling capacitor connected between adjacent wafers conducts the signal from stage to stage.

After testing and frequency adjustment, the entire assembly is dip-potted in Scotch-cast, which leaves a clear conformal coating over the entire assembly. This coating plus the inherent box strength of the assembly renders the unit insensitive to vibrations of 15 g up to 2000 cps and impact shock to 100 g. (Tests beyond these limits were not made.)

The next picture shows the constant-power heater used with one version of the frequency standard. This heater keeps the internal temperature a slight amount above ambient and prevents water vapor condensation. The complete unit measures $1^3/_4$ in. in diam by $4^1/_2$ in. long.

Another version of this unit built for satellite applications where power and size were even more limited measured only $1^5/_8$ in. in diam by $3^1/_2$ in. long, weighed $5^1/_2$ oz, and required only 560 mw of power.

The design of this frequency standard meets the requirements outlined earlier except for repair; but the individual wafers and the assembly as a whole can be tested with such thoroughness that confidence in their reliability becomes very high. The two versions have functioned, for instance, for over 4000 and 5000 hr, respectively, and still operate within the tolerances originally observed.

The individual wafers can be called micromodules since each contains a complete function—that is, oscillator, binary divider or amplifier. Each wafer's functions, in terms of input and output parameters, can be defined; the wafer's performance can be tested and evaluated easily; the wafer uses standard miniature components; and it can be repaired before final assembly.

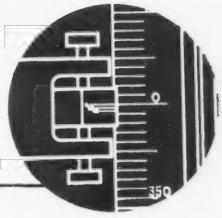
This micromodule technique is particularly well suited to moderate and low volume precision manufacturing. The technique allows a very high component denisty, using 15 to 25 standard components per cubic inch. Finally, and very important, the technique permits fast production of new models, using existing, proved components, to achieve new output frequencies or output characteristics.

1960 Applied Mechanics Congress Set for Stresa

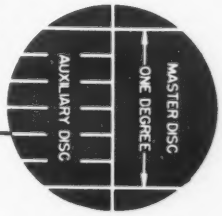
The 10th International Congress of Applied Mechanics will be held at Stresa, Italy, Aug. 31–Sept. 7, 1960. Technical sessions of the Congress will deal with two areas—fluid dynamics (hydrodynamics and aerodynamics) and mechanics of solids (rigid body dynamics, vibrations, elasticity, plasticity, and theory of structures). Four copies of abstracts of papers should be submitted to the Secretary of the International Committee (Prof. Mekelweg 2, Delft, The Netherlands) by Jan. 1, 1960.

WORLD'S MOST ACCURATE DIVIDING HEAD

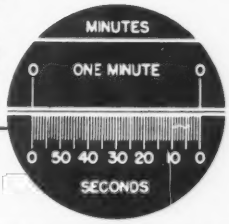
Graduated hand disc for initial rough setting to nearest increment of 20 minutes.



Rotary master disc and fixed auxiliary disc have lines diamond scribed within .000025" of true position. Visible through 40 power scope.

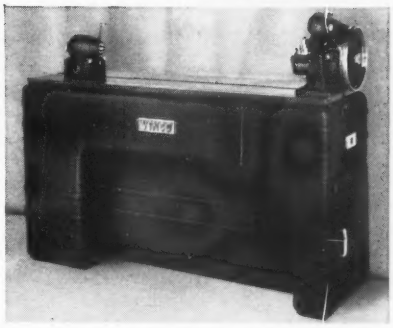


Upper micrometer thimble is divided into 10 minutes of arc. Lower barrel has divisions of both 60 and 10 spaces per minute.

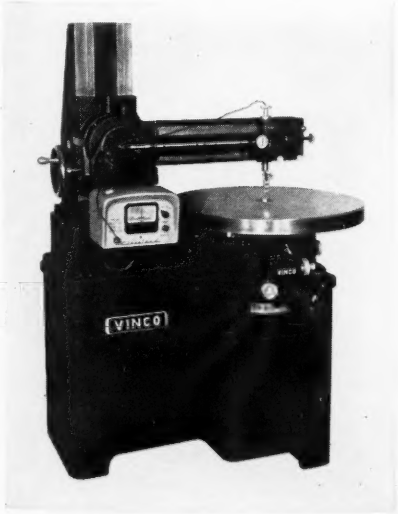


Vinco Optical Master Inspection Dividing Head

For 20 years, the national standard for precision angular measurements and the most accurate industrial turntable. **GUARANTEED ACCURACY:** spindle runout, 25 millionths of an inch (average 15 millionths). • **TOTAL ACCUMULATED ERROR:** 2 seconds of arc (± 1 second). *One second is 1,296,000th part of a circle.* • **MEASURING INCREMENTS:** any required amount of degrees, minutes and seconds. • **APPLICATIONS:** measurement of gear and spline spacing, bore relationships, calibration of index plates, involute and master involute profiles, inspection of any type cam, etc. Years of normal usage will not, and have not altered the extreme accuracy of these instruments.

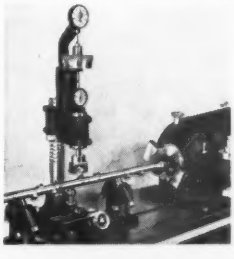


Standard optical dividing heads are available with 20" x 40" or 20" x 72" surface plates of either cast iron alloy or granite. The heavy duty model has a surface plate, cast iron or granite, 36" x 72". Surface plates are hand scraped, have a flatness accuracy of .0002" and are provided with a precision keyway for perfect alignment of tailstock to dividing head.



NEW VERTICAL SPINDLE OPTICAL DIVIDING HEAD

This new instrument embodies the same proven design as the popular standard model, is equipped with a 30 inch diameter turntable and a swivel measuring head. It accommodates larger parts in horizontal position and performs essentially the same inspection functions as the standard model. The measuring head provides readings in increments of .0001".



CAM RISE GAGE measures linear rise or fall of peripheral cams and camshafts within .0001", is available in two sizes, 6" or 9" swing. Special adaptations can be made.

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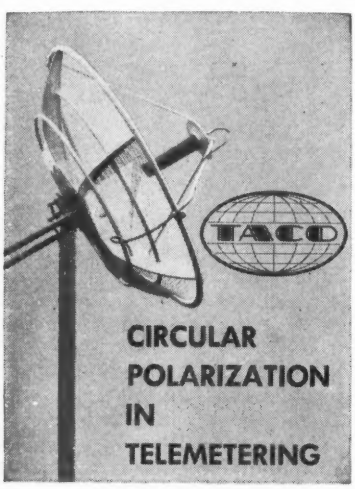

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Missile Market

(CONTINUED FROM PAGE 52)

for design changes, new models, and for the R&D work to develop *new* proprietary products.

Conservative capitalization is also essential. Borrowing can help a company grow without diluting the shareholder's equity, but too much debt can cause a financial crisis under adverse business conditions.

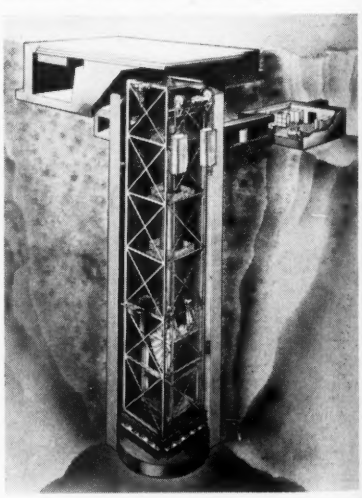
These yardsticks are basic, even simple; in fact, they are frequently overlooked. Where they are rigorously and regularly applied, they will serve the investor well. For while they cannot guarantee him profits, they will help him avoid serious losses.

CAS Proceedings Available

The Canadian Astronautical Society has issued the first volume of the group's proceedings. Edited by J. R. Simpson, the proceedings are available at a cost of $1 from the Secretary, Canadian Astronautical Society, Downsview, Ontario, Canada. Vol. 1, No. 1, contains five technical papers including a history of the Society's CHARM (Canadian High Altitude Research Missile) development program.

Membership in the group has risen to 250. Philip A. Lapp, senior project engineer, de Haviland Guided Missiles Div., is president. Newly elected to the grade of CAS honorary fellow are J. C. Floyd, vice-president, engineering, Avro Aircraft Co., and Andrew G. Haley, IAF President and ARS general counsel.

Minuteman Facility?



Artist's conception of AF underground missile test facility offers a hint as to shape future underground launch pads for Minuteman may take.

BASIC BUILDING BLOCKS

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Systems

For hi-performance hydraulic or pneumatic missile control.

6100 Series Servo Valve

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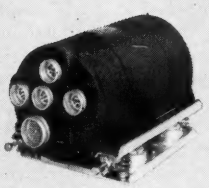
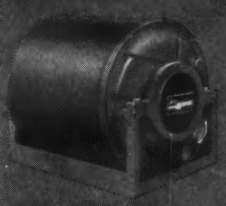


- Great Circle Course and Navigational
- Inertial Position
- Guidance
- Analog and Digital for Missile Applications

Navigational Computer

INERTIAL GUIDANCE



Components include floated gyros, single and two-axis accelerometers, first and second integrators, computers. Complete systems in production for major missile applications feature high accuracy, long-term reliability, light-weight construction.

25 lb. Inertial Platform

GYROS

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- Directional, Conventional and Roll Stabilized
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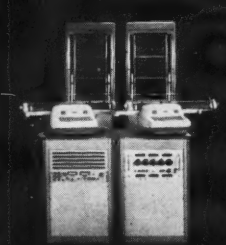
Miniature Floated Gyro

GROUND SUPPORT



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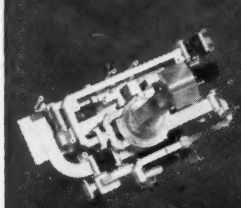
Digital Logging System

MICROWAVE



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In print

Planet Earth by Karl Stumpff, Univ. of Michigan Press, Ann Arbor, 1959, 191 pp. illus. $5.00.

At first glance, it would seem rather unusual to have a review of a book on the earth in a magazine devoted to astronautics. However, the first photo in the book, taken from a V-2 at an altitude of 200 miles and showing a 200,000-sq mi. area of the U.S. and Mexico, is the closest we have yet come in showing earth as a planet moving through space, and suggests how little we actually know about it.

In "Planet Earth," Karl Stumpff, formerly of the Meteorological Institute of the Univ. of Berlin and now professor of astronomy at Göttingen, has combined geophysics and astronomy to provide us with a fascinating rundown on our home planet.

Well-written, easy to read, and informative, the book provides a host of data on the earth's size and shape, its makeup and its relation to the rest of the universe. We learn how the earth moves and how these movements affect the measurement of time and direction finding on the earth's surface. We examine the earth's relationship to the moon and the sun, and have a look at the earth's interior and at the atmosphere which surrounds it. In conclusion, Dr. Stumpff briefly discusses the conditions which produced and sustain life on earth and considers the possibility of life on other planets.

Designed to provide us with a broader understanding of the planet on which we live, "Planet Earth" is deserving of a place in anyone's library.

—I.H.

Space Weapons, a Handbook of Military Astronautics, compiled and edited by the editors of *Air Force* Magazine, Frederick A. Praeger, New York, 1959, 245 pp., illus. $5.

Based to a large extent on the March 1958 issue of *Air Force*, "Space Weapons" takes a full-scale look at military astronautics, a subject much in the news these days. To the articles in that issue have been added a number of new articles, including short essays on space medicine (by Hubertus Strughold), on space vehicles (by Krafft Ehricke) and on military goals in space (by Simon Ramo).

Remarkably devoid of special pleading in behalf of the Air Force, the book covers its subject thoroughly and well. A good portion of the volume is concerned with ICBM technology, on the premise that during the next five to seven years a good part of our national astronautical program will be based on this technology. The Strughold and Ehricke chapters provide a good basic rundown on the problems that lie ahead, while Dr. Ramo, as always, offers a thoughtful and thought-provoking chapter on the importance of making wise decisions in selecting future space missions. *Air Force* Associate Editor William Leavitt, in chapter entitled "Blueprint for Tomorrow's Space Crews," looks at the kind of men that will be needed to man tomorrow's space vehicles and the kind of training they will undergo.

An extra dividend is provided for this handsome and well-illustrated volume in the form of the complete text of the "Primer for Space Technology" issued last year by the President's Science Advisory Committee. A glossary of astronautical terminology and a first-rate bibliography are also included.

—I.H.

BOOK NOTES

Dictionary of Astronomy and Astronautics (439 pp., Philosophical Library, $6) contains more than 2200 definitions of common astronomical and astronautical terms and concepts, with the emphasis heavily on the former—so much so, in fact, that one is inclined to feel the astronautical terms were added as an afterthought. As an example, "rocket" gets only a brief paragraph; "cepheid variables," a full page. Sum-up: A first-rate job on the astronomy end, but not the dictionary of astronautics which is needed.

1959 Directory of Missile Manufacturers (351 pp. in two volumes, Federal Procurement Publications Inc., 10-42 47th Rd., Long Island City 1, N.Y., $25), gives cross-referenced lists of missile manufacturers and companies producing missile hardware and associated equipment. The company has also published a "1959 Directory of Guided Missiles," describing some 180 U.S. rockets and missiles and a number of foreign ones, and a "1959 Directory of Government Missile Agencies," giving addresses of appropriate agencies, field stations, etc., and describing the current missile business and the ABC's of DOD budget and contractural procedures. These two publications are $15 each. The three directories are also offered as a $40 package. Most of the information in these publications is available for the asking from the information services of DOD, the separate military services, and other agencies. A newcomer to the missile business, however, may save himself time and trouble through these compact and generally informative volumes.

Guided Missile Design, edited by Allen E. Puckett and Simon Ramo (497 pp., McGraw-Hill, $10) presents related surveys of fields bearing importantly on guided missile design, with the goal of broadening the knowledge and interest of the specialist in this relatively new realm of engineering. Beginning with the missile system and its components, and broken down finer than given here, these surveys, each by a recognized expert, range through aerodynamics, propulsion, guidance and control, information theory, forms of radio detection and communication, computers and simulators, and system design itself. The chapters are self-contained discussions, economical but not spare, concluding with select references. The book should prove of value to any practicing missile engineer, helping to broaden his thinking and possibly assisting him to reach the point where his design decisions anticipate the needs of his associates.

The Impact of Air Power, edited by Eugene M. Emme (914 pp., Van Nostrand, $12.50), a compilation of essays, public statements, and documents in 12 chapters, each with introductory remarks by the editor, gives its theme in a subtitle, "National Security and World Politics." Three-fourths of the book relates mushroomed military power in the form of aircraft and missiles to the policy of nations, particularly in the Cold War. The last chapter registers the impact of the Sputniks, and offers a preview of expected developments in astronautics and some military implications of satellites and space flight. This chapter reprints most of Krafft Ehricke's "The Anthropology of Astronautics," which originally appeared in the November 1957, ASTRONAUTICS.

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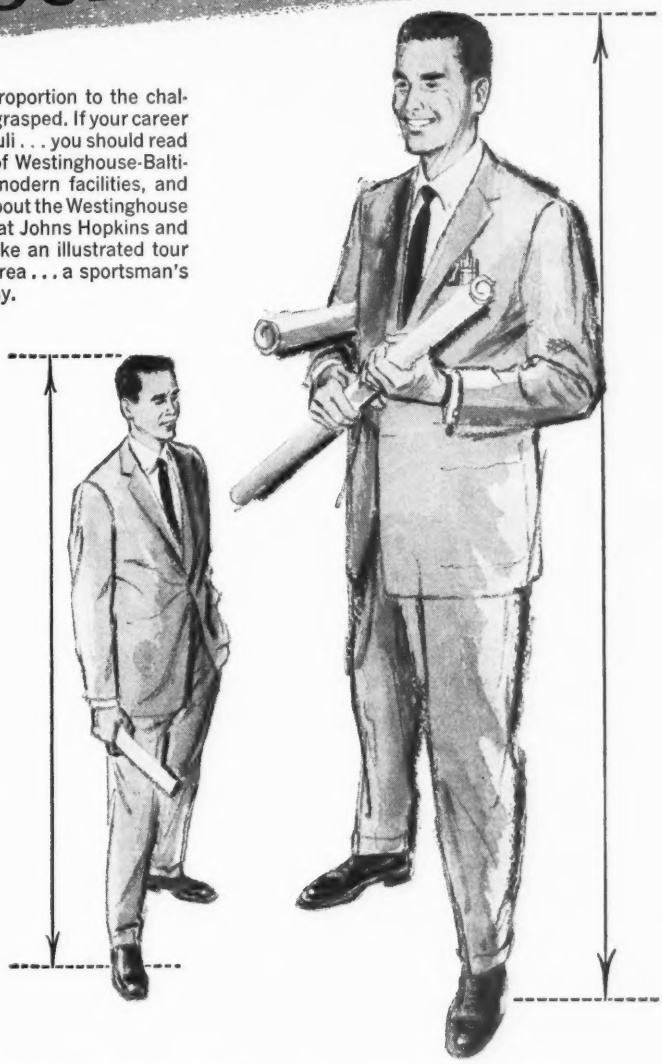

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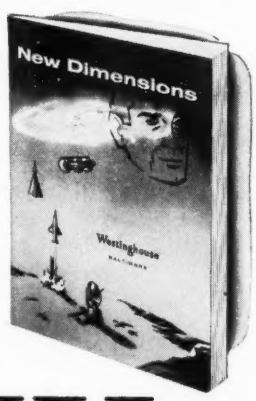

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Price Microminiaturization?

(CONTINUED FROM PAGE 47)

The answer, of course, depends on how we go about it. Let's begin by tackling the propulsion problem. We could attempt to maximize propulsion by upgrading our present vehicles, or by building a new generation of high performance vehicles, which would be still more complicated and more sophisticated than our present vehicles. But complication means less reliability, so this approach represents a dead end in terms of our goal.

Instead, we are getting away from this concept of extremely complicated high performance vehicles. Our present thoughts, in fact, are aimed at greater simplicity, and hence more reliability, even at the cost of considerable increases in over-all vehicle size and weight. It is this philosophy which now underlies most of this country's efforts in the spaceflight field. Simplicity, and hence reliability, is paramount. The cost of the monster which results, rugged and ungainly though it may be, will actually be less than its prettier and more complicated, and hence less reliable, counterpart.

The primary aim now is to achieve maximum reliability irrespective of weight or size. Saturn, the clustered engine booster concept, came out of this philosophy. It is based on the use of simplified versions of presently available, thoroughly tested engines which can be used to provide a simple and reliable booster capable of placing very large payloads in high altitude orbits.

Interestingly enough, clustering a sufficient number of these engines can provide a very high order of reliability, despite the widespread belief that clusters of this type are quite complicated, and hence unreliable. Their use is roughly parallel to the use of multiple engines on aircraft. Many such aircraft have managed to limp home on but two or three of four engines. In a similar manner, a vehicle using a large enough number of rocket engines might accomplish its mission even if one engine failed (non-catastrophically) at liftoff and even if two more failed to function properly once the vehicle had left the ground and achieved a reasonable velocity.

Here again, weight and size are of little importance. The clustered engine booster will weigh more than its single engine counterpart. However, this is because little finesse is being used to connect the engines. Use of the brute force technique means a heavy structure, but one which will do the job, and do it well. Again, the keynote is reliability and simplicity.

The Saturn booster will use clustered fuel tanks derived from those used on an operational missile. They have been thoroughly tested and are regarded as highly reliable. Again, this is an instance of using the state of the art in both manufacturing and technology in order to gain reliability.

To put it as simply as possible, our aim in providing future propulsion for space projects is to come up with a very reliable truck, rather than a temperamental sports car. It will be an all-purpose truck, suitable for a wide variety of different jobs. And, like a truck, it will be made up of standard building block components, rather than handbuilt specialty parts.

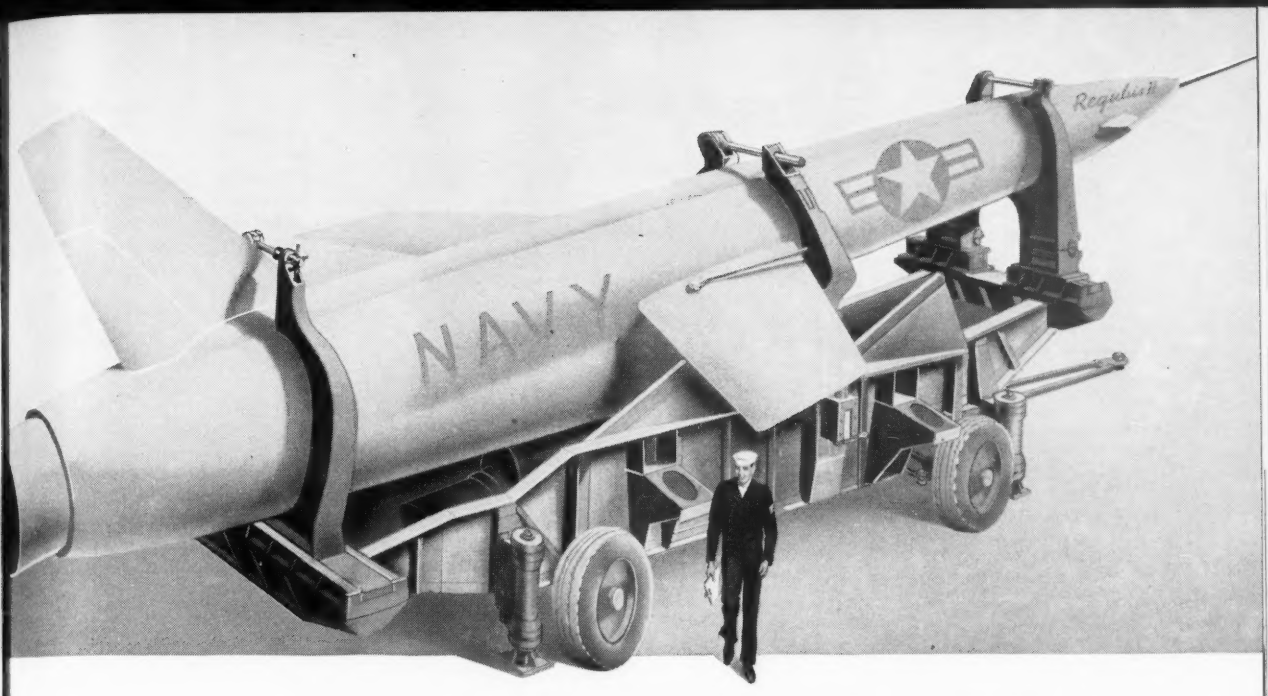
These new vehicles may enable us to reduce the cost of putting one pound of payload in near space from something on the order of several hundred thousand dollars with Vanguard to $1000 or less with vehicles using the current ICBM boosters. In the not too distant future, this figure may be reduced still further to something like $200/lb. Obviously, then, there will be little need for payload components of minimum size and weight from the cost standpoint.

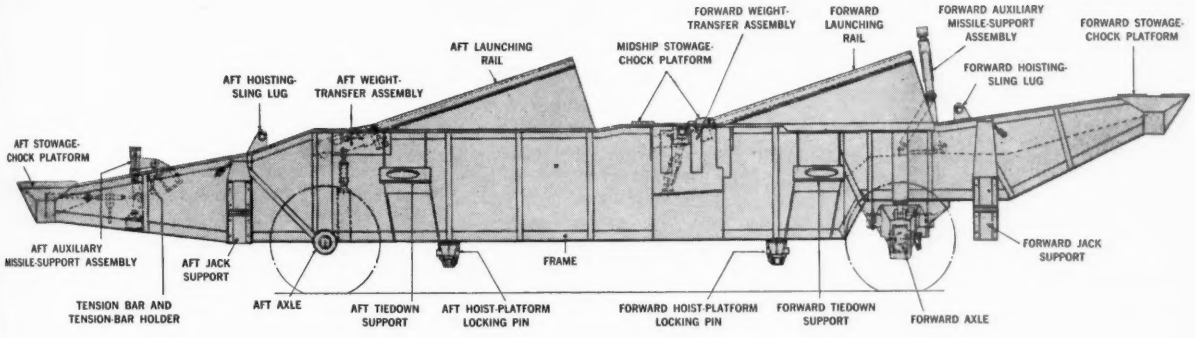
Conclusions

Which brings us once again, the long way round, to the payload. What does all this mean in terms of payload? It means, in effect, that we will have disconnected the vehicle system from the payload system. Instead of designing a new and different vehicle for every new mission, we will have a set of building blocks which can be varied to meet the requirements of a particular mission. We will, at long last, have the simplest and most reliable truck available, and one which might well carry a sign reading: "Mount YOUR Payload Here."

If the truck is made big enough, there will be no overwhelming need for microminiaturization. With, say, from 5000 to 10,000 lb of payload available, we will be able to carry out the multiplicity of experiments demanded by the high cost involved in firing a vehicle of this kind. We will be able to conduct more experiments, gather more data, find out more about space, in a single shot, at a far lower cost, because we can get a bigger package up there in a vehicle with a high degree of reliability.

What is important is determining where you get the maximum return on your investment. Is it better to maximize propulsion or minimize the payload? The answer can only be to maximize as far as possible and minimize as far as possible—as long as the result is high reliability.





Another Loewy missile handling achievement— "Dolly Launcher" for guided missiles on Navy cruisers

Designed and built by Loewy-Hydropress, this vehicle will stow, transport and launch guided missiles from Navy cruisers. As a handling vehicle, the "Dolly Launcher" will cradle and protect the missile against all shock loads imposed by the ship and during stowage and transfer to the launching-training hoist.

Loewy's competence in the design, construction and installation of ground and shipboard handling equipment for missiles of every size and type has been amply demonstrated. One example is its testing and flight-firing installation in connection with this country's participation in the International Geophysical Year. Another is its ship motion simulator for the "Polaris" missile which creates and duplicates the actual movements of a ship at sea. Today Loewy is designing a handling system for the "Terrier" missile to be used on aircraft carriers and the "Talos" warhead handling system for cruisers.

Long experience in machine design, hydraulics, electronics and automation enables Loewy-Hydropress to deal inventively and efficiently with the fast-changing problems of rocket and missile handling. Write Dept. G-5 for specific information.

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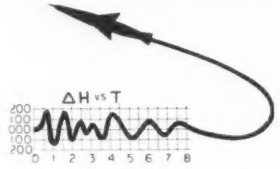
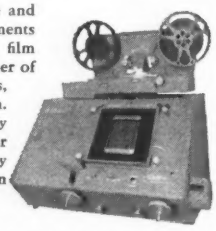


• MISSILES • VIBRATION • MECHANISMS
• BALLISTICS • CONTROLS • MEDICINE
• EXPLOSIONS • RADAR • FLUID FLOW

X-Y coordinate and angle measurements from magnified film images. Number of standard models, 8-16-35-70 mm. Data manually recorded or automatically recorded on cards or tape.



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Piggyback Missiles

(CONTINUED FROM PAGE 33)

as is done on aircraft, by comparing the field at two diametrically opposed parts of the vehicle.

Estimates of the potential of the nose cone indicate that a field mill type of field meter is suitable; the smallest detectable fields are a few volts per meter. A suitable sensitivity range for the instrument is −100 to 100 volts per meter.

Each of the field meters consists of a motor-driven, rotating sector disc which alternately shields and exposes a corresponding sector disc. The induced signal is amplified and detected. Phase reference and, at the same time, a calibration signal is applied by biasing the sector disc. The photo on page 33 shows the field meter.

The modulators (motor-driven chopper discs) are mounted diametrically opposed on the surface of the vehicle, the chopping disc slightly outside the surface and not covered by any material during the measuring period. The amplifier is mounted within the nose cone and adjacent to the modulator. The two outputs from each of the amplifiers are voltages between 0 and 5 volts proportional to field strength. These voltages are integrated and fed into the vehicle's telemetry system. Each amplifier is 3 by 3 by 2 $^1/_2$ in. The timer unit is 3 by 3 by 3 $^1/_2$ in.

Ion and electron density. Knowledge of local ion and electron densities in the upper atmosphere is important in understanding such physical processes as electromagnetic propagation, nature of the sources of ionization, photochemical reactions, and origin and nature of inhomogeneities in the concentration of charged particles. It is also of considerable interest to measure the charge distribution in the ion sheath adjacent to the surface of the nose cone.

The experiment consists of direct measurements of local ion and electron densities by means of two spherical probes mounted diametrically opposite one another on the surface of the nose cone. Each sensing element consists of a spherical condenser. The outer electrode is a grid-like surface with a high open-to-surface area ratio; the inner sphere is a solid conductor. The voltage on each condenser is programmed in the following manner. For 30 sec a constant voltage of approximately 200 volts is maintained between the plates of the condenser. This voltage is great enough to collect, on the inner sphere, all ions of appropriate sign which enter the outer sphere. During a subsequent 30 sec a variable voltage is applied between the outer sphere and the nose cone surface. The resulting current-voltage curve can be interpreted using the probe theory developed by Langmuir and Mott-Smith to obtain electron densities and electron temperatures. This programming of the voltage is repeated once each minute.

An important advantage of this experiment over propagation measurements is that it provides local rather than integrated values of charge densities. It is therefore particularly suited to studying the electrical fine structure of the upper atmosphere.

Each amplifier unit is 4 by 4 by 3 in. The variable voltage unit is 3 by 3 by 3 in. Total weight of the instrumentation, including probes, is 6 lb. The outer diameter of the sensing probe is 4$^1/_2$ in.; it is mounted on an arm 12 in. from the surface of the nose cone.

A logarithmic DC amplifier will be used to measure currents between 10^{-5} and 10^{-10} amp, corresponding to ion and electron densities in the concentration range 100 to 10^8 per cc. The outputs are signals in the range 0 to 5 volts which are fed into the vehicle's telemetry system.

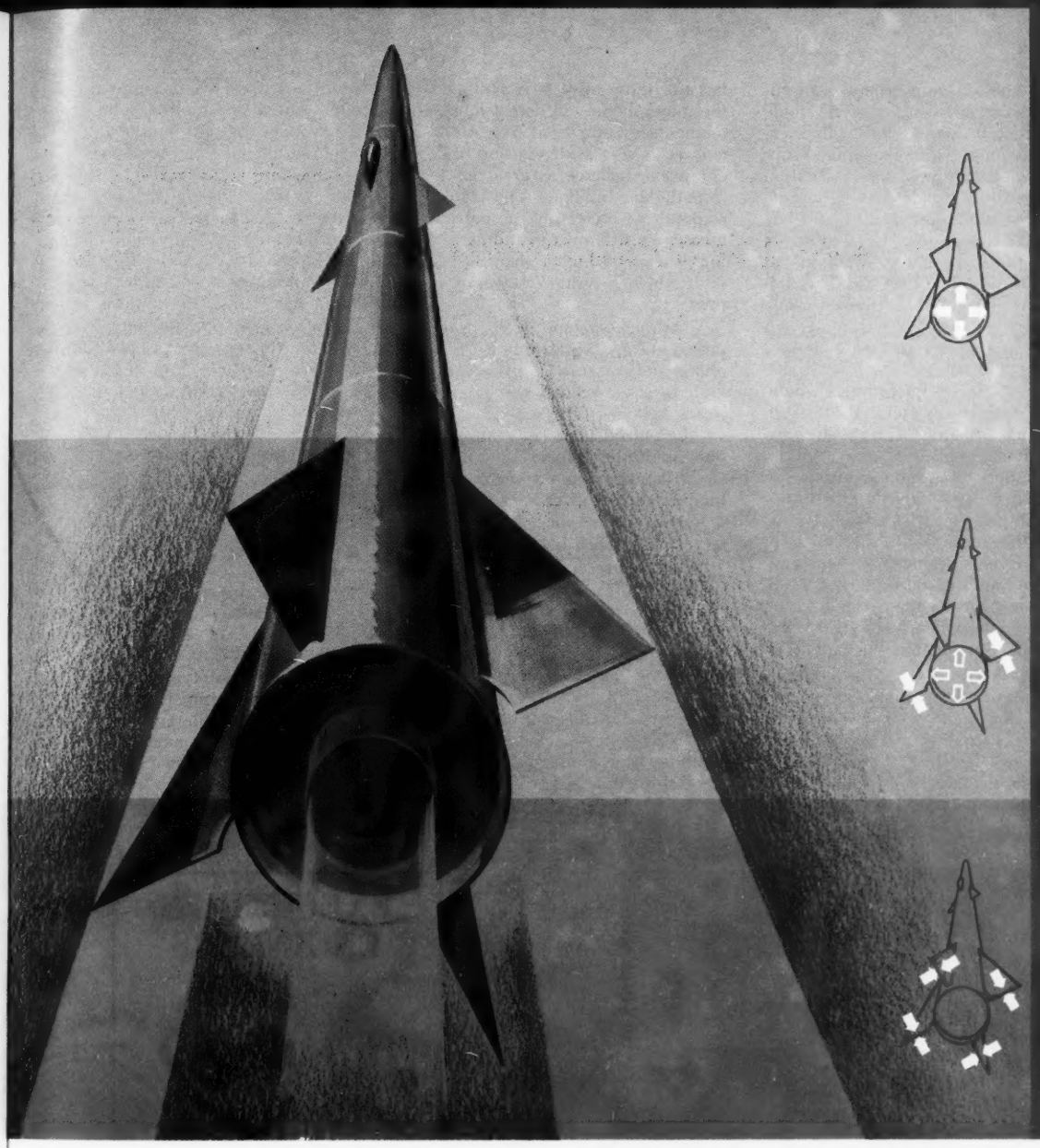
Micrometeorite detection by grids. Grid detectors are used to measure the destructive effects of extraterrestrial dust particles as well as the number of impacting particles with radius greater than a theoretical minimum. The wire grid detectors consist of ten coils of 17 micron diameter enameled wire wound on flat forms and connected in parallel. The electrical continuity of the grids is monitored during flight. If a wire on any coil is broken, continuity in a part of the circuit is broken and the resultant change fed into the telemeter system as a discrete change of voltage.

Unit Weighs 100 Grams

Shown on page 33, this unit, exclusive of batteries, weighs approximately 100 grams and provides 50 sq cm of detecting area. Power for operation is 28 volts at 1 milliamp.

It has been concluded from tests at the Ballistics Research Lab that wires of the grid impact detector would certainly be broken by particles of less than 50 micron diameter impacting at a velocity between 10 and 14 km/sec. From experiments at lower velocities, it is expected that the grids might be sensitive to meteoritic particles of diameter as low as 7 microns.

Micrometeorite detection by microphone. This experiment is designed to measure the total number of dust particles that strike a surface while outside of the earth's atmos-



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phere. The sensing element is an impact detector consisting of a single PZT-5 Brush crystal of cylindrical shape and mounted in a machined support such that the over-all vibration resonances are tuned to an ultrasonic frequency range centered at 100 kc/sec. The transducer is capable of withstanding continual operation at temperatures up to 500 F. This microphone in operation is pressed firmly against an exposed metal plate. A particle striking the surface generates a mechanical pulse which is transformed into an electrical pulse which, in turn, normally is amplified through three tuned stages of transistor circuitry giving an over-all gain of 90 db. The microphone amplifier output signal is fed to a bi-stable multivibrator whose output levels are adjusted to be within the required telemeter input range. Events are recorded by sampling the multivibrator output level. Shown on page 33 the complete unit, including microphone, amplifier, multivibrator, and battery, weighs 160 grams.

The sensing element has been calibrated using single particles impacting with velocities from 10 to 4×10^5 cm/sec and has been found to have an output dependent on the momentum of the impacting particle. On the basis of these tests, it is assumed that the microphone will detect impacts of momenta greater than 5×10^{-5} gm/cm/sec over a wide sensing area, including a distance as great as 60 cm from the microphone. This would correspond to detecting a particle of greater than 3 micron radius impacting at a speed higher than 30 km/sec (i.e., above average meteoric velocities).

Artificial meteor flash. In this experiment, an attempt will be made to obtain and measure an artificial meteor flash in a very small distance of the rocket surface. This will be done with an aluminized lucite disc placed on a photomultiplier tube. When a particle strikes the top surface of the aluminized disc, it gives a flash of light in a small interval of space. This is measured by the photomultiplier.

In operation, light pulses strike the photomultiplier, which produces negative voltage pulses. These are fed to a four-stage RC-coupled transistor amplifier which has a nominal gain of 65 db with additional tapped outputs of −30 and −60 db. These pulses are fed to a quantizing unit consisting of three identical monostable multivibrators whose inputs are derived from these three different sources separated by 30 db in level. The quantizing multivibrators have a common output such that if one multivibrator is fired the voltage output is one volt. For each additional stage that is fired, the voltage output increases by one volt per stage. This voltage is negative with respect to ground with a pulse width of approximately 1000 microsec.

The sensitivity of the first quantizing multivibrator is approximately 25 millimicroamp which, in terms of light sensitivity, is approximately 10^{-13} lumens striking the photomultiplier cathode. Total weight of the unit is approximately 2.1 kg, including batteries.

Many Tests to be Made

A sufficient number of experiments will be flown to insure consistency of the data, to allow for readjustment of sensor sensitivity, and to obtain an indication of these seasonal variation of some of the measured quantities.

The piggyback program has great potential for the science-engineering team of space vehicle designers. It enables the prototype missiles themselves to supply much of the environmental design criteria for the subsequent production models. A large part of this information otherwise would be unobtainable in time to be practical.

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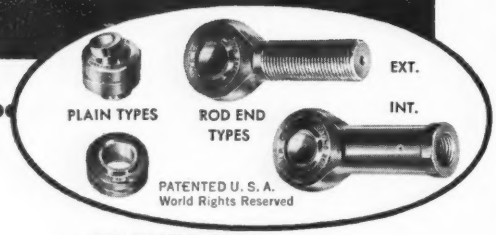

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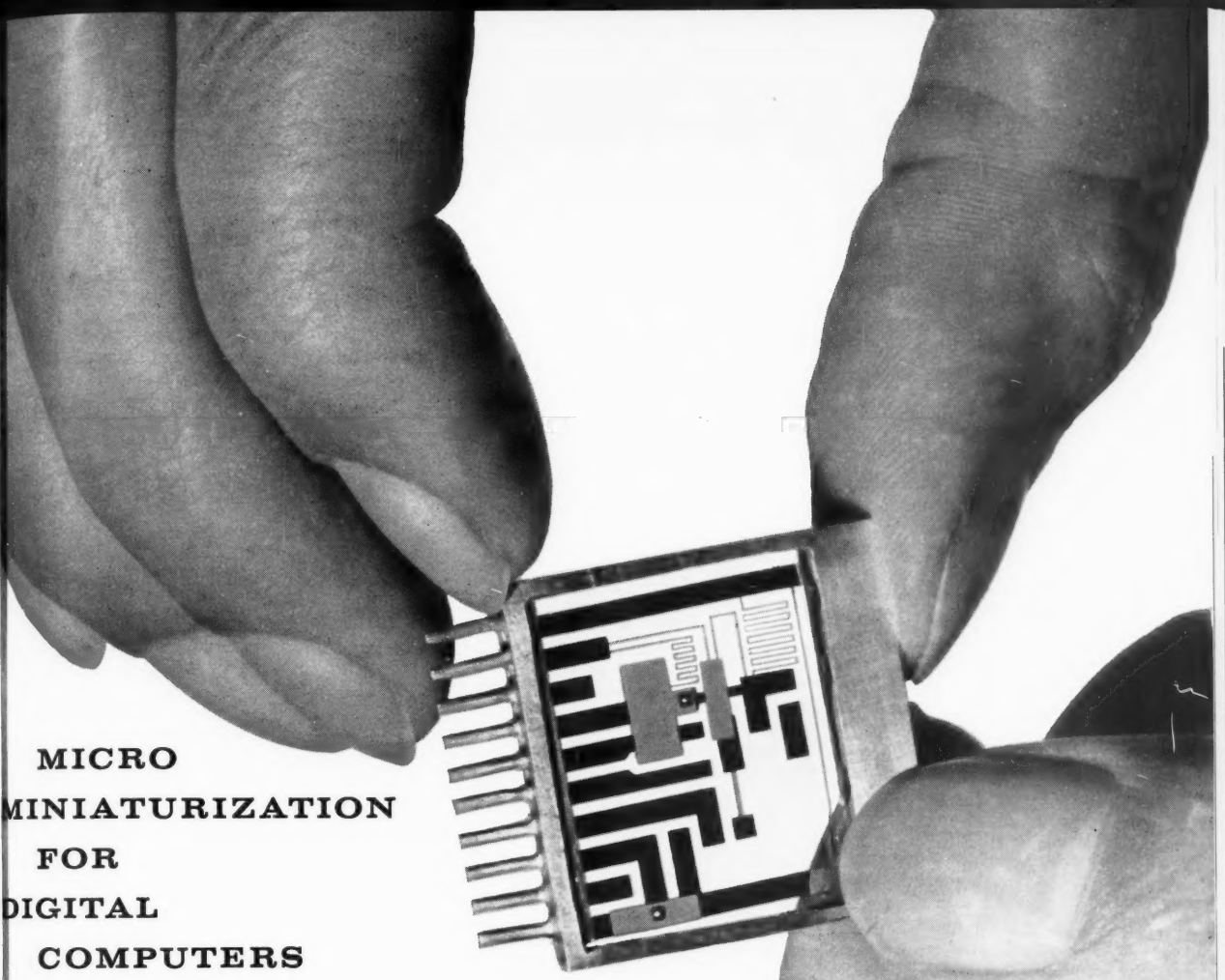

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Government contract awards

NASA Contracts for February

NASA wrote $11.9 million worth of R&D contracts during February. Largest was $10.5 million contract with McDonnell Aircraft for Project Mercury, expected to cost about $15 million. Other contracts were with Smithsonian Institution, $470,000 for electronic and data reduction equipment; Aerojet General, $170,000 for shipping rigs for Aerojet Senior boosters to be used in Project Scout, a four-stage all-solid propellant test vehicle; and Minneapolis-Honeywell Regulator, $770,000 for the Project Scout guidance system.

Thiokol Receives $77 Million Minuteman Contract from AF

A $77 million AF contract has been let to Thiokol Chemical for three stage development of the Minuteman solid propellant rocket propulsion system. Thiokol says that some 61 per cent of the work will be subcontracted.

GE Gets Vega Job

NASA has awarded GE a $5 million contract for development of a liquid propellant engine to power the second stage of the Vega space vehicle, which will be combined with an Atlas vehicle as the first stage.

Nike-Zeus R&D by Lear

Lear Inc. has received a $6.7 million contract from Bell Telephone Labs for R&D in connection with the Army's Nike-Zeus.

$93 Million Pact to Grumman

A $93 million development and production contract for a new Navy propjet early warning plane, W2F-1, has been awarded Grumman Aircraft Engineering Corp.

Mace Contract to Martin Co.

The AF has awarded a $2,400,000 contract for expansion of its TM-76B Mace missile program to The Martin Co. Baltimore Div.

ICBM Decoys

Aeronutronic Systems has been awarded a $2,327,000 contract by the AF Ballistic Missiles Div. for development and testing of decoys in support of the ICBM program.

Missile-Guidance Radar

Navy's BuOrd has awarded Sperry Gyroscope a $51.9 million job for production of missile-guidance radars to be installed on ships equipped with the latest version of Terrier missiles.

Drone Guidance Systems

AF has assigned a $7.5 million production contract to Sperry Phoenix for remote guidance and control systems for pilotless QF-80 jets.

Wallops Island Expansion

Daniel, Mann, Johnson, & Mendenhall, Los Angeles architects and engineers, have received an estimated $2 million design contract in NASA's expansion program for the Missile Research Station, Wallops Island, Va. DMJM will design two universal launch emplacements, a blockhouse, and a static test facility.

Anti-Missile Defense Study

Solar Aircraft has been awarded an Army Ordnance study contract in the field of anti-missile defense, as a result of a new approach developed by Solar and proposed to ARPA.

High Strength Steel Sheet

An initial $100,000 Navy contract has been awarded to Lukens Steel for R&D in the production of widest possible high strength steel sheet for rocket engine casings at the lowest possible cost.

Wind Tunnel Control System

CDC Control Services, Inc., has received an ABMA contract to furnish a complete pressure control system for the blow-down wind tunnel at Redstone Arsenal, Ala.

Republic Gets R&D Contract

Republic Aviation has received a $725,000 AF contract for 15 months of research for development and evaluation of high temperature hydraulic system components capable of operating from 65 to 600 F; testing and evaluation of aircraft fasteners capable of withstanding temperatures as high as 1200 F; preparation of a manual for analysis of high temperature aircraft and spacecraft structures; and testing of a pilot ejection seat capsule at subsonic and supersonic speeds.

Titan Contract to AMF

The Air Force has awarded a $12,125,000 follow-on contract to American Machine & Foundry for design and development of training base launchers for the Titan, bringing AMF's work on the program to a total of $42 million.

Jupiter Telemetry

ABMA has awarded a $303,458 contract to Motorola Military Electronics Div. for AN/DKT-8 (XO-4) telemetry systems to be used in the Jupiter missile program.

Dunlap Named Associate

Aeronutronic Systems has named Dunlap and Associates, research and consulting firm, an associate contractor for consultation on a Navy contract involving instrument planning for the Pacific Missile Range.

ADD-ON AND SUB-CONTRACTS

Design & development of training base launchers for Titan, $12,125,000, **American Machine & Foundry,** from Air Force.

Switch timing and monitoring systems for use with CAPCHE on the Atlas, $200,000, **Epsco-West,** from Convair.

Rocket catapults for B-58, $300,000, **Gabriel Co. Talco Div.,** from Convair.

Hydraulic reservoirs for Hound-Dog support equipment, **Horkey-Moore Associates,** from North American Aviation.

F-101 Autopilots, $8,000,000, **Minneapolis-Honeywell Regulator,** from AF Air Material Command.

Spike control systems for B-58, $1,900,000, **Minneapolis-Honeywell Regulator,** from Convair.

Phase-Lock receivers, $280,000, **Motorola Military Electronics Div.,** from Space Technology Labs.

Liquid oxygen tanking computers for Jupiter, **Servomechanisms, Inc.,** from Chrysler Corp.

Rocket engine mounts, heat exchangers, hood assemblies for Thor and Jupiter, **Solar Aircraft,** from North American Aviation Rocketdyne Div.

Sintered-plate, nickel cadmium batteries for missiles and jets, $1,800,000, **Sonotone Corp.,** from Air Force.

Precision gyroscopes for Bomarc, $438,600, **Telecomputing Corp.,** from Boeing.

SYNOPSIS OF AWARDS

The following synopsis of government contract awards lists formally advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army, and Navy contracting office:

AIR FORCE

AF Cambridge Research Center, ARDC, Laurence G. Hanscom Field, Bedford, Mass.

Research in satellite tracking, $35,523, **Kansas State College of Agriculture and**

Applied Science, Engineering Experiment Station, Manhattan, Kan.

Research for furtherance of geodetic knowledge by observing artificial earth satellites, $97,575, **Itek Corp.,** 700 Commonwealth Ave., Boston, Mass.

Development of method of computation permitting determination of orbital elements, $36,328, **General Dynamics Corp.,** Electric Boat Div., Groton, Conn.

Research on the detection of infrared emission from satellite vehicles, $44,885, **ITT,** ITT Labs Div., 15151 Bledsoe St., San Fernando, Calif.

Research on precise geodetic data from observations of artificial earth satellites designed specifically for geodesy, $30,275, **Systems Laboratories Corp.,** 14852 Ventura Blvd., Sherman Oaks, Calif.

AF Missile Development Center, ARDC, Holloman AFB, N.M.

Rocket engines and rocket motors used in support of missile test track project, $426,572, **Grand Central Rocket Co.,** Box 111, Redlands, Calif.

AF Missile Test Center, ARDC, Patrick AFB, Fla.

Increase in funds, $2,612,343, **Pan American World Airways,** 135 E. 42 St., Chrysler Bldg., New York 17, N.Y.

Increase in funds, $39,516, **Morton Schiff Co.,** 601 Virginia Dr., Orlando, Fla.

Increase in funds, $35,000, **Barnes Engineering Co.,** 30 Commerce Rd., Stamford, Conn.

Pulse code modulation telemetry recording system, $192,000, **Dynatronics, Inc.,** 717 W. Amelia Ave., Orlando, Fla.

AF Office of Scientific Research, ARDC, Washington 25, D.C.

Continuation of research on low energy (1–10 mev) nuclear research with a tandem Van De Graaff, $246,740, **Florida State Univ.,** Tallahassee, Fla.

Research on theoretical and experimental investigations in high speed aerodynamics, $129,000, **Cornell Univ.,** Ithaca, N.Y.

Research on the study of the origin and propagation of disturbances in the burning of solid propellants, $33,150, **Stanford Research Institute,** Menlo Park, Calif.

Continuation of research on nonlinear theories of deformation and buckling, $100,760, **New York Univ.,** Washington Square, New York 3, N.Y.

Continuation of research on electron flow in plasmas and high density beams, $33,333, **Polytechnic Institute of Brooklyn,** Brooklyn 1, N.Y.

Research on molecular fragments in shock waves, $50,340, **Univ. of Michigan,** Ann Arbor, Mich.

AMC Aeronautical Systems Center, Wright-Patterson AFB, Ohio.

Facilities in support of missile tank test program, $998,300, **Beech Aircraft Corp.,** Wichita, Kan.

ARMY

Boston Ordnance Dist., Army Base, Boston 10, Mass.

Gyro accelerometers for Hawk missile, $152,954, **Raytheon Mfg. Co.,** Andover, Mass.

U.S. Army Engineer Dist., Jacksonville, Corps of Engineers, 575 Riverside Ave., Jacksonville, Fla.

Design of Minuteman facilities, $87-000, **Alexis B. Kononoff,** 620 N.W. 32 St., Miami, Fla.

U.S. Army Engineer Dist., Los Angeles Corps of Engineers, 751 S. Figueroa St., Los Angeles 17, Calif.

Lox generator facility at Vandenberg AFB, Lompoc, Calif., $330,345, **Bovee Inc.,** 15134 S. Indiana Ave., Paramount, Calif.

U.S. Army Ordnance Dist., Los Angeles, 55 S. Grand Ave., Pasadena, Calif.

Rocket engines, $412,500, **North American Aviation,** 6633 Canoga Ave., Canoga Park, Calif.

Launching area items, $690,000, **Douglas Aircraft,** 3000 Ocean Park Blvd., Santa Monica, Calif.

Study of hypervelocity impact, $47,-972, **North American Aviation,** Missile Development Div., 12214 Lakewood Blvd., Downey, Calif.

Design and development, $160,000, **North American Aviation,** 6633 Canoga Ave., Canoga Park, Calif.

U.S. Army Signal Supply Agency, 225 S. 18 St., Philadelphia 3, Pa.

Research and experimental work for 24 months directed toward obtaining more reliable communications in the high frequency range from 2 to 30 mc, $241,-101, **Developmental Engineering Corp.,** Washington, D.C.

Prototype surveillance systems, $200,-000, **Texas Instruments,** Dallas, Tex.

Phase I and II of TR-CSD-23-59 for short range surveillance drone system, $995,000, **Rheem Mfg. Co.,** Downey, Calif.

Purchasing and Contracting Div., White Sands Missile Range, N.M.

Vibration test system, $186,790, **Ling Electronics,** 9937 Jefferson Blvd., Culver City, Calif.

NAVY

District Public Works Officer, Sixth Naval Dist., Bldg., 13, U.S. Naval Base, Charleston, S.C.

Addition to the Minitrack satellite tracking station, transmitter site bravo, Jordan Lake, Montgomery, Ala., $57,-490, **Carr & Rothschild,** Inc., P.O. Box 204, Montgomery, Ala.

Navy Dept. Bureau of Ordnance, Washington, D.C.

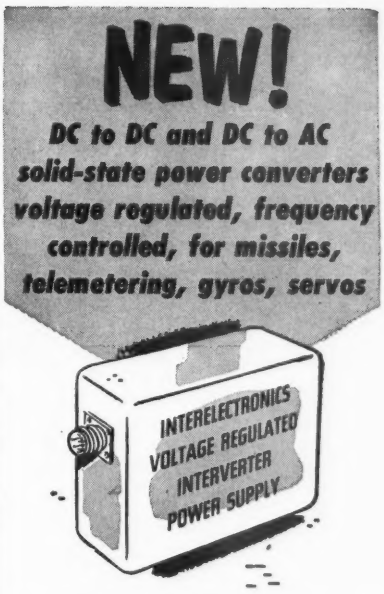
Acquisition, installation, and maintenance of facilities for use in conduct of research and development of solid propellants, $107,000, **American Cyanamid Co.,** Research Div., New York 20, N.Y.

Office of Naval Research, Washington 25, D.C.

Research on high altitude balloons, $32,595, **General Mills,** Minneapolis, Minn.

U.S. Naval Research Laboratory, Washington 25, D.C.

Magnetic recording tape, $26,330, **Minnesota Mining and Mfg. Co.,** 900 Bush Ave., St. Paul 6, Minn.



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Radar Contact with Venus

(CONTINUED FROM PAGE 50)

duces an uncertainty of 50,000 miles in Earth-Venus distance at closest approach.

The importance of refining the astronomical unit can be seen in this comment in the Rand Corp. report on "Astronautics and Its Application," submitted to the House space committee in December 1958. "No vehicle using initial guidance alone is likely to make a hit on any of the planets (except by accident) until the length of the astronomical unit is better known in terms of earth standards usable in guidance systems. The expected miss in shots to Venus and Mars, from this source of error, is likely to be many tens of thousands of miles. . . .These physical constants of primary relevance to astronautics are part of the general family of astronomical constants, and any improvement in their precision will be reflected in improvements in others."

Preliminary calculations from the Venus experiment indicate that the astronomical unit may be 0.0013 per cent smaller than currently estimated.

In addition to these landmarks in radar astronomy, the Venus experiment introduced other major technical advances: (1) First reported application of the solid-state maser amplifier in a practical instrument; (2) first application of the solid-state maser in either passive or active radio astronomy; (3) first instance of solid-state maser operation at frequencies as low as the UHF band; and (4) first reported application of digital computer signal processing in radio astronomy.

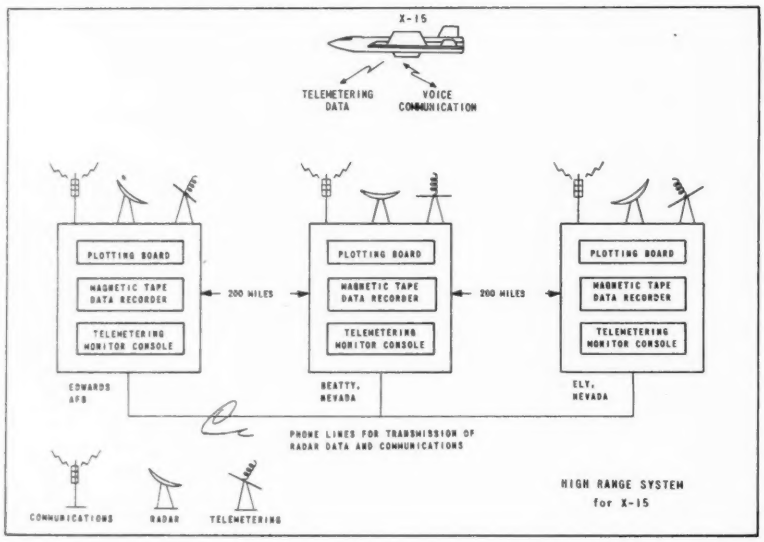
Signal Data

Note should be made of the signal strengths in this experiment and the method of signal detection. As mentioned, signals were transmitted with a pulse power of 265 kw (peak power of 300 kw). It was estimated that Venus intercepted about $^1/_2$ watt, and the signals received were of the order of 10^{-20} watt. These signals were buried in the internally generated noise of the receiving equipment and the background noise of atmospheres and space. They were brought to relief against this noise by a sophisticated statistical method of signal analysis known as "cross correlation," in which the long coded train of pulses constituting the signal was compared at every point with background noise by a high speed digital computer. This process filters out a set of correlation functions, which show a statistically significant peak representing the received signal as distinguished from noise. It was established by this method that there is less than one chance in 10 million that the correlation for the Venus experiment could be attributed to accidental selection of a noise pattern, rather than the true signal.

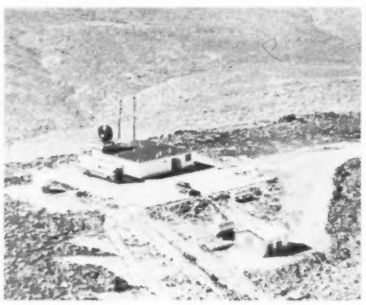
Many members of the staff of Lincoln Lab contributed to the foresight and virtuosity of the Venus experiment. Paul Green Jr. and Robert Price led the research group. Robert H. Kingston designed and developed the maser employed.

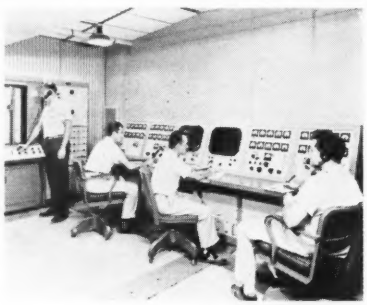
The Lincoln group plans further radar study of Venus late this summer, with the aims of refining distance measurement and establishing the as yet unknown surface character and the rate of rotation of our bright but visually unplumbable neighbor planet.

High Range System Ready for X-15



Above, diagram of the High Range system. Below left, aerial photo of Beatty station with Mud Lake, a possible emergency landing area for the X-15, in background. At right below, a plotting board and monitor console in the High Range system.

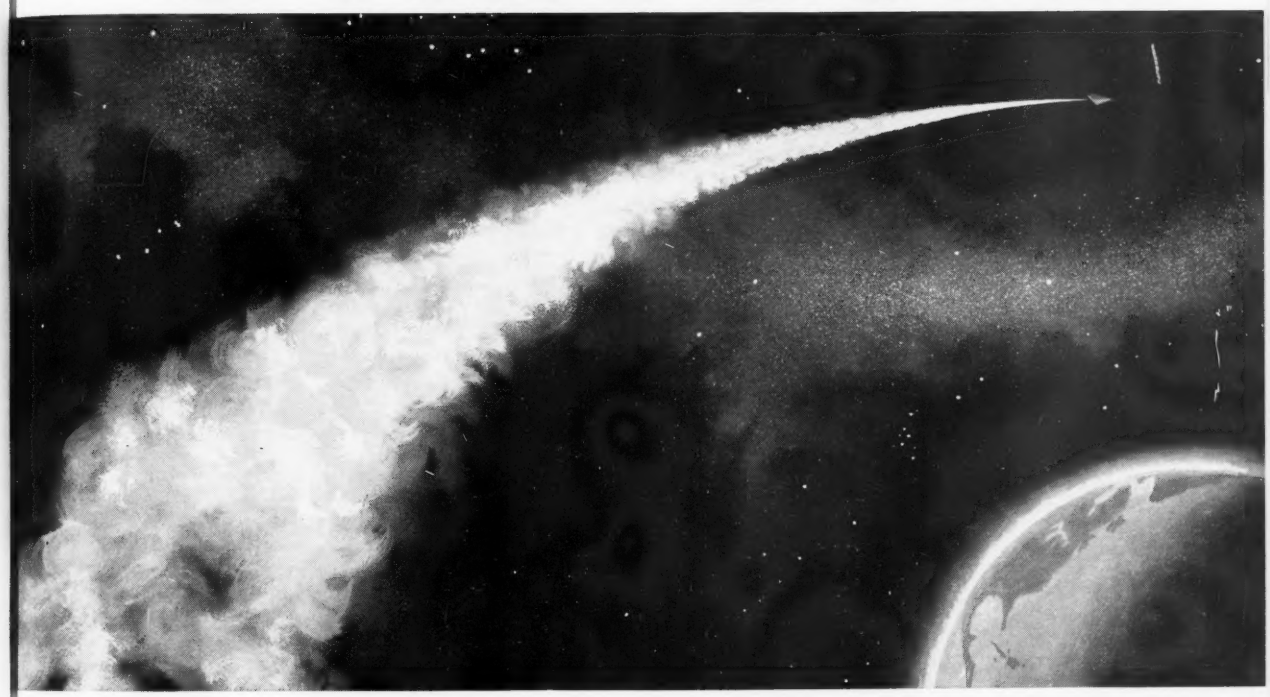




When the X-15 rocket-powered aircraft zooms some 100 miles into the upper atmosphere later this year, its progress will be followed by radar, voice communication, and telemetering through High Range—the constant-communication tracking network developed by Electronic Engineering Co. for the Air Force and succeeding to NASA Jan. 1. Besides tracking the X-15, High Range will constantly check pilot and vehicle, at a rate of as much as 600,000 responses per sec, on everything from pilot heat rate to aircraft skin temperature profile. All UHF transmitters in the system air simultaneously and are interconnected by long distance telephone lines.

Datum, an automatic data recording and processing system developed by the company, will reduce all data from X-15 flights to usable form in 30 hr. The same amount of data used to take more than 30 days with manual data reduction. The master control center for High Range will be at the NASA High Speed Flight Station at Edwards AFB, Calif.

DYNA-SOAR



Dyna-Soar (for dynamic soaring) is a joint project between the Air Force and the NASA, and is an attempt to solve the technical problems of manned flight in the sub-orbital regions. Advance knowledge on the project indicates how a boost-glide vehicle can operate from the outer fringes of the atmosphere where it can maneuver and be recovered undamaged. Studies show that by varying the original rocket boost, and thus the velocity, and with the control available to the pilot, the Dyna-Soar aircraft can circumnavigate the earth, followed by a normal and controlled landing. Boeing Airplane Company, one of the competing companies for the development contract for the complete boost-glide system, has delegated to RCA the responsibility for the development of important electronic components of Dyna-Soar.

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DEFENSE ELECTRONIC PRODUCTS

CAMDEN, N. J.

Beyond Microminiaturization

(CONTINUED FROM PAGE 45)

ized television cameras, computers, and similar devices, which are, indeed, the basis of many telemetry and reconnaissance equipments used in airborne and satellite communication links.

But the trend of research is to go beyond the adaptation of existing commercial products and components to space vehicle payloads. Current research seeks, rather, an order-of-magnitude microminiaturization by the use of inhomogenous solid-state materials, or integrated electronics. It aims to synthesize materials with controlled internal fields, molecular spin resonances, and phenomena resulting in rectangular hysteresis loops into single components which may perform several electronic functions, such as amplification, oscillation, detection, and visual display. Materials which accomplish these functions separately are already accomplished entities, but have been used heretofore as discrete elements interconnected by wires or at best by printed circuitry. It remains for research to integrate these materials into a reproducible unitary structure that will be free from the shock and vibration problems of space vehicle launch.

Examples of other potentially useful solid-state phenomena may include Faraday rotation in special ferrites for microwave isolators and power dividers, crystalline masers for microwave amplification, and parametric amplifiers using tiny semiconductor voltage-dependent capacity diodes, the latter also being ideal for microminiature frequency modulators. Ferromagnetic (ferrites, magnetic films), ferroelectric (barium titanate, guanidine aluminum sulfate hexahydrate), photoconductive (cadmium sulfide) and piezoelectric (quartz) materials will ultimately be integrated into space electronic devices and systems.

A further step must be taken, however, before research can give a truly microminiature system for space vehicles. This entails the invention or evolution of an electronic *system* which utilizes the utmost sophistication of communication theory and circuit ingenuity to provide a highly specialized system with a minimum of elements.

Megacoder

To illustrate this integration of device and system, using presently attainable components, a microminiature selective-interrogation decoder, having a function capacity of one million at interrogational speeds of 5000 per min and occupying less than 1 cu in. in volume and consuming about 50 mw from a 7-volt source, will be described.

This RCA Lab development, the Megacoder, although intended for personal selective calling, can provide a similar function in space vehicles. It is described in some detail because the techniques used in it can be incorporated in telemetry ring samplers, coincidence circuits, and many other electronic devices.

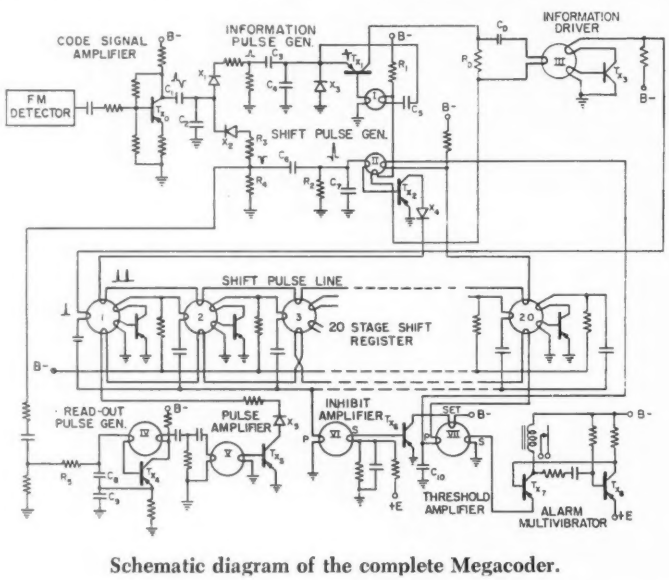
The Megacoder uses a digital system incorporating a binary code with pulse return to zero. Digital systems have a basic advantage in accuracy over analog systems. The price paid for accuracy is the increased complexity and number of elements to attain the desired coding capacity. The modulation consists of a discrete combination of positive and negative pulses which produce a coding capacity of $C_d = 2^N$, where N equals number of pulses. Transistor-magnetic core mechanization was used for the Megacoder.

The illustration on page 44 shows the modulation waveforms of two subscribers', or function codes, in time sequence. Here a 20-digit bipolar binary code is used, effecting a subscriber capacity of 2^{20} or 1,048,576 codes. The table on this illustration relates subscriber capacity with the number of coding pulses from $N = 4$ (equivalent to 16 subscribers) to $N = 24$, which allows 16,777,216 subscribers to use a single radio channel. The complete call consists of a coding interval using bandwidth-limited bipolar coding pulses and a readout or recognition pulse whose duration is approximately half the total coding interval, or sufficiently long to allow separation of this pulse from an all-positive or all-negative pulse by simple circuitry. The polarity of the recognition pulse may be either positive or negative, so that its leading edge may serve as one of the coding digits, as shown. The subscribers' call number may be assigned on a binary numbering system consisting of five groups of four pulses representing 2^0, 2^1, 2^2, and 2^3.

The use of both polarity pulses has the advantage of providing N shifting or clock pulses regardless of code, thus eliminating the need of an internal synchronized oscillator in each receiver. The transmitter thus effectively supplies the "clock" or "synchronizing" signals for thousands of receivers, which simplifies their design and reduces their cost.

To conserve channel bandwidth and simplify the modulation problem, pulses approximating half-cosine waves are advantageously used. For the Megacoder, a 19-millisec coding interval plus an 18-millisec bipolar readout pulse will allow a coding speed of approximately 1600 codes per min. For unlimited bandwidth the ultimate coding speed depends on the transistor alpha-cutoff frequency and core switching time, and approaches 20,000 codes per min.

The next figure shows one stage of the shift register used in the Megacoder. This is an encapsulated element, 0.017 cu in. in volume, consisting of an 80-mil ferrite core with five windings, a 2N105 transistor, a resistor, and a capacitor. The same figure also shows a typical hysteresis curve (B vs. H) illustrating high rem-



Schematic diagram of the complete Megacoder.

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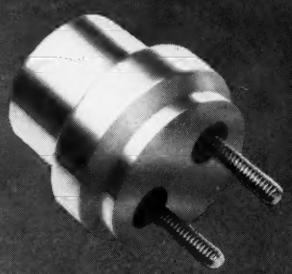
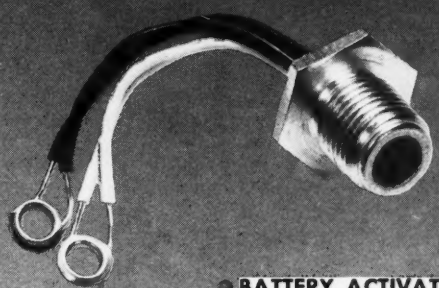
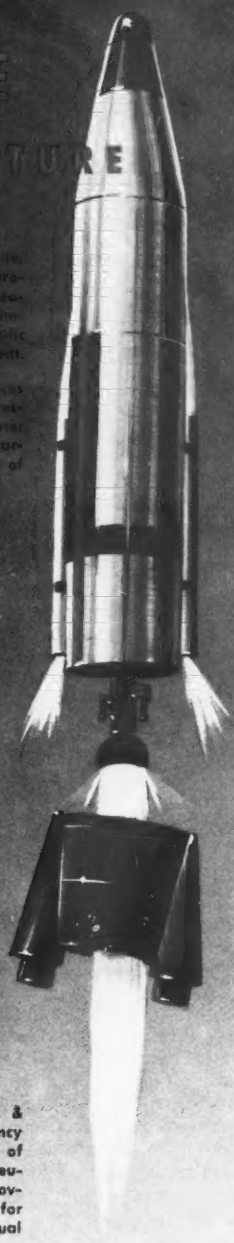
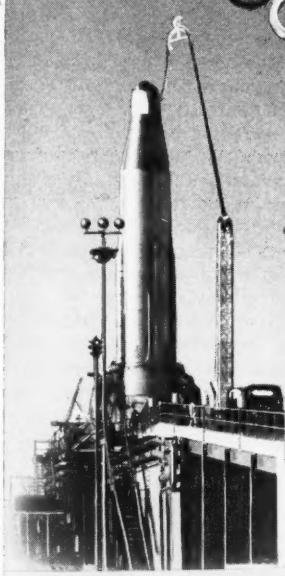


M-92 PRESSURE CARTRIDGES



BATTERY ACTIVATION CARTRIDGES





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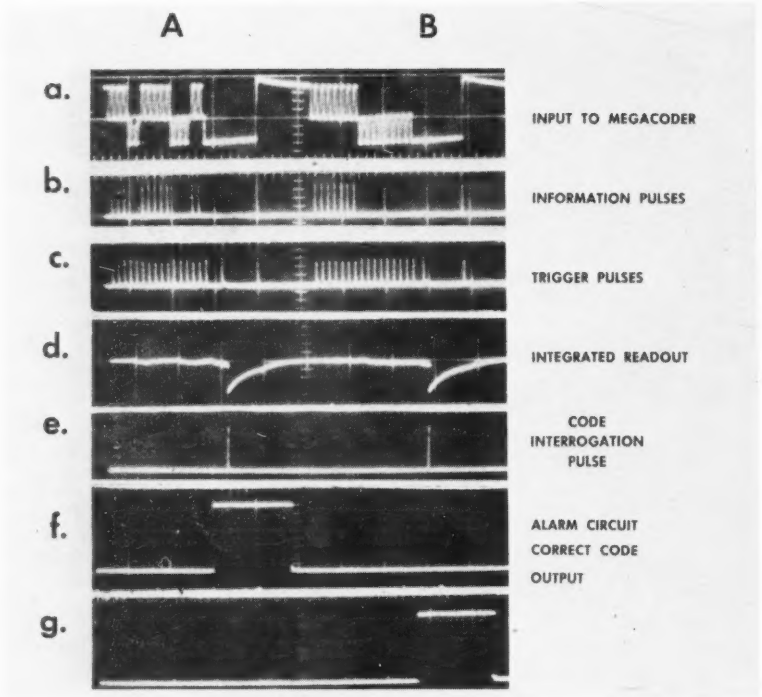


Oscillograms of key waveforms of the Megacoder.

anance magnetization and a curve of permeability ($\mu = K\ dB/dH$ vs. coercive force, H). This latter characteristic is important in the Megacoder method of information transfer and readout.

This type of shift register has proved very successful because of the small trigger drive required, extremely low power consumption, reliable setting, and no reasonable limit to the number of stages. The latter advantage results from the power regeneration in each stage by means of one transistor rather than the use of two equally expensive diodes.

A schematic circuit diagram of the complete Megacoder arranged to correspond to the block diagram shown previously appears on page 45. The code signal preamplifier incorporates negative feedback for temperature stability and an output filter for optimizing signal to noise performance. The information (+) and trigger (−) pulses are separated and each fed to a transistor–magnetic core pulse generator, thus converting the broad signalling pulses into 3-μsec processing pulses.

The information pulses are fed to the first stage of the 20-element shift register, while the negative and reversed positive pulses are fed into the series trigger line of the shift register. If the readout pulse is negative, the integrator circuit is fed by voltage pickoff after the negative diode, and similarly from the positive diode for a positive readout.

The integrator circuit drives a transistor-core pulse generator such that, when a voltage threshold has been reached, this circuit fires, producing a very narrow pulse in series with all the readout windings of the shift register. Each of these windings is brought out to a miniature terminal board and the polarity interconnection of these windings constitutes the subscribers' code. The comparison of the coercive force polarity and the magnetic state of each core due to the received code constitutes the logic of the system, as described previously. If coincidence occurs due to the reception of a correct code, the magnitude of the resulting pulse current is sufficiently large to exceed the threshold of a very square core of large coercive force, whose primary winding is in series with the shift register readout windings.

The secondary of this threshold amplifier core is connected to the quiescent emitter of a transistor monostable multivibrator, in whose collector circuit is a fast-acting relay which actuates a spring-wound alarm. Therefore, with the reception of a correct code, the alarm circuit is instantaneously set off and can be so adjusted that manual turnoff is necessary. To insure that the alarm be not activated during the coding interval, the return-to-ground line of all the discharge capacitors of the shift register is in series with a winding on the inhibit amplifier core. The polarity of this winding is so arranged that capacitor current due to core switching inhibits circuit actuation.

The photo series at left shows oscillograms of key waveforms of the Megacoder—the input voltage, information pulses, trigger pulses, the integrated readout pulse, the code interrogation pulse, and the alarm multivibrator output-circuit waveforms for two subscribers' correct codes. In (f) of the photo series, the Megacoder is set to respond to the code signal at the left of (a), and (g) responds to the right hand signal of (a).

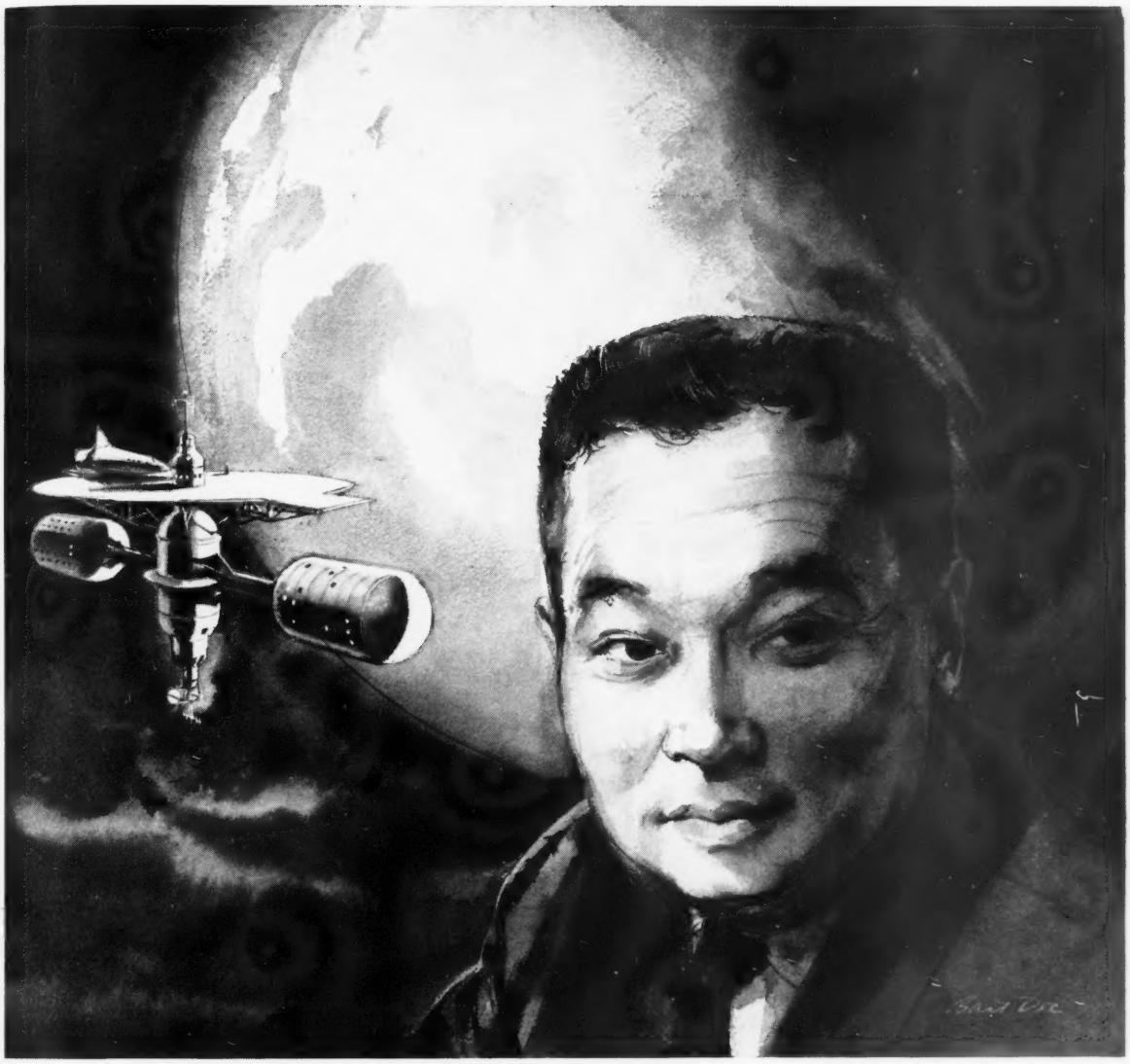
Photographs of the modularized Megacoder by itself and incorporated in a miniature RCA-CPC-R1 receiver appear on page 45 . This type of modular packaging can be improved by the micromodule techniques described in the article by H. J. Laiming and J. W. Knoll on page 34. But ultimately the point of diminishing returns with modular techniques will be reached; for in tomorrow's interplanetary vehicle, size and weight will be more critical than today and electronic devices will have to operate reliably over long periods with extreme economy of power. Then there will be need for an even more compact and integrated electronics.

Solid-State Register

A first step in the direction of device integration has been made in the form of a solid-state shift register, shown in the photos on page 45, together with a miniaturized conventional shift register, an important element in data handling systems. The integrated solid-state register consists of 10 Thyristor-type transistors made into a single piece of semiconductor material including the interconnecting passive components. The result is a single microminiature element which performs the functions of 10 transistors, 20 resistors, and 10 capacitors.

In the developmental version of this register, a bar of germanium 0.00004 cu in. in volume performs the functions of short-term memory as well as the basic transistor functions. Since this circuit can be also used as a "ring" stepping or commutating function, an extremely small and rugged satellite telemetry system or computer can be made using it.

Looking well beyond the present research state, we can foresee the application of this technique to complete microminiature electronic control and guidance systems of great versatility. Such systems consisting of integrated building blocks might enable us to include in a missile or satellite many



Y.C. Lee

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of the computational and analysis functions which are now excluded because of lack of room.

In the field of sensors, the development of microminiature photoconductors, including ones for the infrared spectrum, will lead to improved signal-to-noise performance as well as reduction in size, since this parameter is proportional to the square root of the area (PbS) and $\sqrt{V}$ for metallic (i.e., doped germanium) photoconductors. This assumes that the energy can be suitably focused on the microscopic element or matrix of elements. Development of scanning techniques utilizing some of the "integrated" components as well as the use of miniaturized vidicons can be effectively used for satellite and spacecraft reconnaissance.

This brief discussion touches only some of the area of investigation of microminiaturization of electronics for space age use. Yet even this little area suggests that a decade hence the "integration" process may indeed have produced electronic equipment which in complexity, volume, sophistication, and power consumption approaches the human brain.

Suggested Additional Reading

Future Circuit Aspects of Solid-State Phenomena, E. W. Herold. Proc. Symposium on Solid-State Phenomena in Electric Circuits, B.P.I., New York, April 23, 1957. Contains 29 references.

The Megacoder—A High Speed Large Capacity Microminiature Decoder for Selective Communication, H. Kihn and W. E. Barnette, RCA Review, March 1959.

Integrated Electronic Devices, J. T. Wallmark, Research and Development Handbook, 205 East 42 St., New York, 1958–1959.

Space Medicine Electronics Symposium Set for May 18

Space Medicine Electronics will be the topic of an all-day symposium to be held at the Franklin Institute May 18 in Philadelphia. Eight prominent speakers will discuss the need for new concepts in electronic equipment applicable to space medicine. Adm. John T. Hayward (USN) Deputy Chief of Naval Operations for R&D, will give the luncheon address.

Among the scheduled speakers are William H. Boghosian, associate director of the Institute for Cooperative Research, Univ. of Pennsylvania; Theodore Kaslow, vice-president in charge of engineering, Decker Corp., Phila.; John L. Brown, Aviation Medical Acceleration Lab, Johnsville, Pa.

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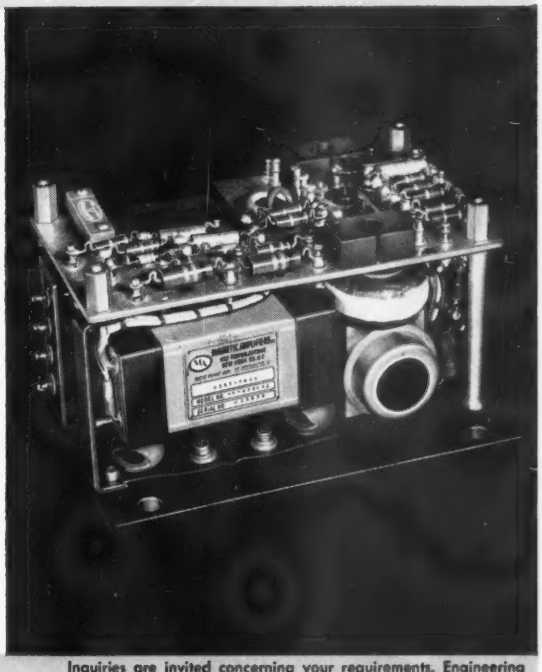

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12 Technical Sessions, Exhibit of Components and Equipment

Twelve technical sessions will highlight the National Telemetering Conference, to be held May 25–27 at the Cosmopolitan and Brown Palace Hotels in Denver, Colo. The conference, devoted to "Investigation of Space," is co-sponsored by ARS, AIEE, IAS, and ISA. Among the topics to be covered are telemetry system integrity, miniaturization and transistorization, components, ground stations, data processing, bio-medical telemetry, measurement and control, and RF components and techniques.

Included among the 12 technical sessions are two panel discussions, one on the "Past, Present, and Future of Space Investigation," and the other on "The Future of Telemetering." Other highlights of the meeting are two luncheons and a banquet, and a special exhibit of telemetry equipment and components.

The full program follows:

Monday, May 25

CRITIQUE AND COMPARISON OF VARIOUS TELEMETRY SYSTEMS FOR SPACE INSTRUMENTATION

9:00 a.m. — **Silver Glade Room, Cosmopolitan**

Chairman: John Eckhart, Sandia Corp., Albuquerque, N.M.

✦Communication Efficiency Comparison of Space Telemetry Systems, R. W. Sanders, Space Electronics Corp., Glendale, Calif.

✦Comparative Merits of Analog and Digital Telemetering, L. C. Watson and Melvin Goldstein, Texas Instruments, Inc., Dallas, Tex.

✦New Developments in PCM Telemetry, R. E. Marquand, Radiation, Inc., Melbourne, Fla.

✦The Influence of FM-FM Telemetry Component Characteristics on System Performance, O. J. Ott, Data-Control Systems, Inc., Danbury, Conn.

✦A Comparison of an Identical Vacuum and Transistor Telemetry System, M. A. Lowy, Data-Control Systems, Inc., Danbury, Conn.

TELEMETRY SYSTEM INTEGRITY

9:00 a.m. — **Club Room, Cosmopolitan**

Chairman: Wilfred M. Koellish, The Martin Co., Denver, Colo.

✦A System Approach to a Low Cost Telemeter, D. R. Weber, Bendix Aviation Corp., N. Hollywood, Calif.

✦Distortion in FM-FM Telemetry Systems and Its Effect on System Accuracy, Walter O. Frost, Army Ballistic Missile Agency, Redstone Arsenal, Ala.

✦High Accuracy Telemetry of Inertial Guidance Performance, John F. Meyer, Jet Propulsion Laboratory, Pasadena, Calif.

✦Accuracy and Reliability of the Sandia 220 MC Telemetry System, James H. Scott, Sandia Corp., Albuquerque, N.M.

✦Some Considerations of the Effects of Nuclear Radiation Environments on Precision Airborne Instrumentation, John Rau G. M. Giannini Co., Inc., Pasadena, Calif.

12:15 p.m. — **Main Ballroom, Brown Palace**

LUNCHEON

Toastmaster: Max A. Lowy, Chairman, 1959 National Telemetering Conference.

Speaker: Comdr. Robert F. Freitag, Naval Air Missile Test Center, Pacific Missile Range, Point Mugu, Calif.

MINIATURIZATION AND TRANSISTORIZATION PROGRESS

2:30 p.m. — **Club Room, Cosmopolitan**

Chairman: James Wynhoff, Telemetering Corp. of America, Sepulveda, Calif.

✦Effect of Transistor Parameter Variations on Performance of Low Level Amplifiers, W. L. Thompson, Texas Instruments, Inc., Dallas, Tex.

✦A Variable Inductance Modulator for Transistorized FM/FM Sub Carrier Oscillators, C. E. Land, Sandia Corp., Albuquerque, N.M.

✦A Solid State Multiplexer and PCM Encoder, R. C. Baron, T. P. Bothwell, and R. J. Sutherby, Epsco, Inc., Boston, Mass.

✦A Transistorized Active Low Pass Filter with One CPS Corner Frequency, R. C. Onstad, Convair-Astronautics, San Diego, Calif.

✦Semi-Conductor Device Operation in a Pulsed Nuclear Environment, J. D. Maxey, R. P. Pecoraro, and W. A. Bohan, International Business Machines Corp., Owego, N.Y.

SPECIAL TELEMETRY TECHNIQUES

2:30 p.m. — **Silver Glade Room, Cosmopolitan**

Chairman: T. D. Warzecha, Convair-Astronautics, San Diego, Calif.

✦Results of Real-Time Vibration Analysis Using an Airborne Analyzer, A. S. Westneat Jr., Applied Science Corp. of Princeton, Princeton, N.J.

✦Some Coding Methods for Conserving Band Width, L. Zuckerman and I. Ross, United Electrodynamics Corp., Pasadena, Calif.

✦PCM/PS Telemetry System, E. Niemann Jr., General Electric Co., Philadelphia, Pa., and H. N. Putschi, General Electric Co., Syracuse, N.Y.

✦A New Approach to Sub-Carrier Pre-Emphasis, Walter E. Hane, The Martin Co., Orlando, Fla.

✦Voltage Transfer Low Level Commutation System, Merril Martin and Walter Phillips, Texas Instruments, Inc., Dallas, Tex.

Tuesday, May 26

TELEMETRY COMPONENTS—GENERAL

9:00 a.m. — **Silver Glade Room, Cosmopolitan**

Chairman: Charles E. Ruckstuhl Jr., Bendix Aviation Corp., Wilton, Conn.

✦The Design of a Practical Pre-Transmission Analyzer for Telemetry Application, A. R. Ratz, Applied Science Corp. of Princeton, Princeton, N.J.

✦A Transfer-Function Computer, J. N. Brown, Applied Science Corp. of Princeton, Princeton, N.J.

✦A Low Level, High Speed Sampling Switch, E. J. Young, Magnavox Co., Los Angeles, Calif.

✦Definition of Parameters Applicable to Transducer Specifications, J. S. Hernandez, Statham Instruments, Inc., Los Angeles, Calif.

✦Variable Reluctance DC Transducer, O. K. Kowallis, Wiancko Engineering Co., Pasadena, Calif.

GROUND STATIONS—TECHNIQUES AND NEW COMPONENTS

9:00 a.m. — **Club Room, Cosmopolitan**

Chairman: K. A. Hall, Space Technology Laboratories, Los Angeles, Calif.

✦High-Density Magnetic Tape Recording of Digital Data M. A. Wells, Consolidated Electrodynamics Corp., Pasadena, Calif.

Set for Telemetering Conference in Denver May 25-27

✦Tradecom—A Transistorized PAM Decommutator, P. R. Palmer, Sandia Corp., Albuquerque, N.M.

✦A Deviation Standard for FM Systems, Herschel J. Wood Jr., White Sands Missile Range, N.M.

✦A Trailer-Installed Flight Test Monitoring and Control Station, S. F. Higgins, Consolidated Electrodynamics Corp., Pasadena, Calif.

✦Telemetry System for Vandenberg Air Force Base, R. E. Hadady and R. F. Tullis, Aerojet-General Corp., Azusa, Calif.

PANEL DISCUSSION—PAST, PRESENT, AND FUTURE OF SPACE INVESTIGATION

2:30 p.m. **Silver Glade Room, Cosmopolitan**

Chairman: Max A. Lowy, Data Control Systems, Inc., Danbury, Conn.

William H. Pickering, Jet Propulsion Laboratory, Pasadena, Calif.

George E. Mueller, Space Technology Labortories, Los Angeles, Calif.

John P. Hagen, National Aeronautics & Space Administration, Washington, D.C.

F. J. Krieger, The Rand Corp., Santa Monica, Calif.

DATA PROCESSING AND PRESENTATION

2:30 p.m. **Club Room, Cosmopolitan**

Chairman: C. Benavides, The Martin Co., Denver, Colo.

✦Processing and Presentation of Space Data, J. M. Seehof and B. W. Washburn, Space Technology Laboratories, Los Angeles, Calif.

✦An Automatic Instrumentation Analog Data Processing Facility, E. Hoeff and N. F. Bowling, Chance Vought Aircraft, Inc., Dallas, Tex.

✦An Analog On-Line Data Reduction System for Engine Testing, J. D. Dunlop and D. L. Dresser, Allison Div., General Motors Corp., Indianapolis, Ind.

✦Simple Computation Techniques for Telemetry Data Reduction Systems, George Birkel Jr., Radiation, Inc., Melbourne, Fla.

✦Application of Digital Data Processing to PDM and FM Telemetry Data, W. E. Leever, Douglas Aircraft Co., Santa Monica, Calif.

RECEPTION

6:00 p.m. **Silver Glade Room, Cosmopolitan**

BANQUET

7:00 p.m. **Silver Glade Room, Cosmopolitan**

Toastmaster: Max A. Lowy, Chairman, 1959 National Telemetering Conference.

Speaker: Maj. Gen. O. J. Ritland, Air Force Ballistic Missile Div.

Award: 1st Annual National Telemetering Conference Award

Wednesday, May 27

PANEL DISCUSSION—THE FUTURE OF TELEMETERING

9:00 a.m. **Silver Glade Room, Cosmopolitan**

Chairman: W. J. Mayo Wells, National Bureau of Standards, Washington, D.C.
Hans K. Ziegler
Army Research and Development Laboratory
Fort Monmouth, N.J.
Victor Hammond
Hq., Air Research and Development Command
Andrews AFB, Md.
Kenneth B. Pendleton
Bureau of Aeronautics
Washington, D.C.
L. W. Gardenhire
Radiation, Inc.
Melbourne, Fla.
Robert Djorup
Epsco, Inc.
Boston, Mass.
J. M. Snodgrass
Scripps Institute of Oceanography
La Jolla, Calif.
Eberhard Rechtin
Jet Propulsion Laboratory
Pasadena, Calif.
William Dow
Woods Hole Institution of Oceanography
Woods Hole, Mass.
E. T. Ramm
Signals Research and Development Establishment
Christchurch, England
Bernard Luskin
La Monte Geological Observatory
Palisades, N.Y.

SPACE TELEMETERING—BIO-MEDICAL

9:00 a.m. **Club Room, Cosmopolitan**

Chairman: A. I. Dranetz, Gulton Industries, Metuchen, N.J.

✦The Future of Physiological Telemetry in the Space Age, M. A. McLennan, Wright Air Development Center, Wright-Patterson AFB, Ohio

✦The Requirements of Bio-Medical Monitoring in Space Flight, R. W. Lawton, General Electric Co., Philadelphia, Pa.

✦Physiological Transducers for Measurements in Space Vehicles, Walter Welkowitz, Gulton Industries, Metuchen, N.J.

✦Bio-Medical Measuring Circuitry, J. T. Powell, Army Ballistic Missile Agency, Redstone Arsenal, Ala.

12:15 p.m. **Main Ballroom, Brown Palace**

LUNCHEON

Toastmaster: Allan P. Gruer, Program Chairman, 1959 National Telemetering Conference.

Speaker: Col. George M. Wertz, Army Combat Surveillance Agency.

SPACE TELEMETERING—MEASUREMENT AND CONTROL

2:30 p.m. **Silver Glade Room, Cosmopolitan**

Chairman: Otto Hoberg, Army Ballistic Missile Agency, Redstone Arsenal, Ala.

✦The Transmission of Microwave Telemetry Signals from a Re-Entering Vehicle, Keith Baldwin, Avco Manufacturing Co., Wilmington, Mass.

✦Parameters and Techniques Applicable to Ultra Long Range Communication with Solar System Probes, J. J. Downing, Lockheed Missiles and Space Div., Palo Alto, Calif.

✦A Coherent Minimum-Power Lunar Probe Telemetry System, B. D. Martin, Jet Propulsion Laboratory, Pasadena, Calif.

✦Space Navigation by Correlation, Paul Zilczer, Fairchild Astrionics Div., Wyandanch, N.Y.

✦Termination of Trajectories for Human Probes, C. J. Mundo, American Bosch Arma Corp., Garden City, N.Y.

RF COMPONENTS AND TECHNIQUES

2:30 p.m. **Club Room, Cosmopolitan**

Chairman: J. H. Smith Jr., Texas Instruments, Inc., Dallas, Tex.

✦Radio Links for Space Flight, J. H. W. Unger, Army Ballistic Missile Agency, Redstone Arsenal, Ala.

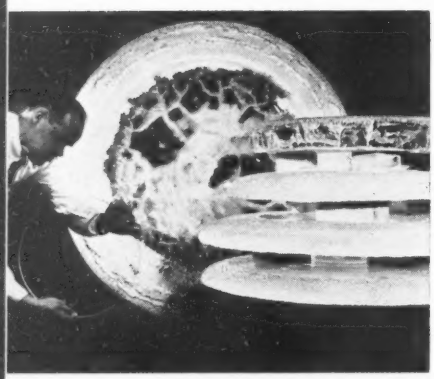
✦Ultra-Linear Transistorized FM Transmitter, R. E. Lee, Texas Instruments, Inc., Dallas, Tex.

✦A State-of-the-Art Receiver for 2200 MC Telemetry, Hans Scharla-Nielsen and Sydney E. Smith, Radiation, Inc., Melbourne, Fla.

✦Miniaturized Telemetry Slot Antennas for Missile Applications, Malcolm Yaffe, General Electric Co., Philadelphia, Pa.

✦R. F. Multiplexing of Telemetry Transmitters, W. H. Harrison, Rantec Corp., Calabasas, Calif.

New equipment and processes



Ultrasonic Delay Lines: Very short and extremely long delay times are features of the Corning ultrasonic delay lines which store a signal with minimum attenuation for periods of 50 to 15,000 microsec. The glasses used have nearly a zero temperature coefficient of time delay; they are manufactured by the same techniques used to produce optical glass, and therefore can be formed into standard glass shapes. Corning Glass Works, Corning, N.Y.

Micrometer: An ultraprecise micrometer has been developed to have an accuracy of ±0.000010 in. Two standard ranges are available—0 to 1 in. and 0 to 2 in. Graduations on a 4 in. barrel are arranged for reading right or left, normal or reverse. The Sheffield Corporation, Dayton 1, Ohio.

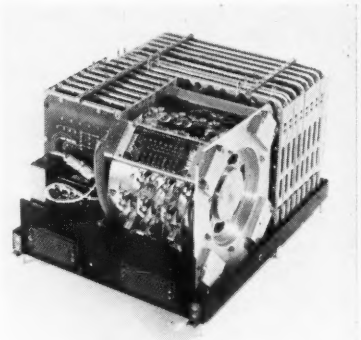
High "G" Cardiograph: An advanced 3-channel electrocardiograph system for the rocket sled at Holloman AFB will simultaneously record data prior to and after sled runs. The system is designed for stresses up to 200 g. It records data involving any three of the standard limb and precordial leads of both humans and animals. Edin Div. of Epsco, 588 Commonwealth Ave., Boston 15, Mass.

Instrumentation Recorders: The CV-100 series of recording equipment can simultaneously record seven complete channels of video information, each of which requires 1-mc bandwidth.

Data can be acquired for a 15-min period on a single reel of $\frac{1}{2}$ in. tape. Tape speed of 120 ips allows 12 min of running time, using standard 1-mil tape; reproducible timing accuracy is 0.005 per cent. Output signal level is 2 v at 93 ohms of impedance. The rack-mounted system is powered by 117-v line power at 60 c. The instrument has only 12 moving parts. 3M Mincom Div., 2049 So. Barrington Ave., Los Angeles, Calif.

Target Tracking: The Vector Miss-Distance Scoring System, AN/GSQ-29 (XI-1), determines the real-time trajectories and relative positions of target, missile, and interceptor from Cubic Corp. angle-measuring equipment. A Bendix G-15 general purpose computer performs the trajectory calculations, and computes the escape and burst distances. To reduce the cost of pilot training, simulated missions in place of real rocket firings can be scored. Computer Div., Bendix Aviation Computer Div., 5630 Arbor Vitae St., Los Angeles 45, Calif.

Airborne Computer: Silicon-transistorized throughout, a lightweight, multifunction digital computer solves many navigational problems in both aircraft and missiles. The AN/ASN-



24 is immune to a wide range of environmental extremes, and handles data from RACAN, celestial, inertial and Doppler information, radio, true-airspeed systems, and heading instruments, all in a single unit. Librascope Inc., 808 Western Ave., Glendale 1, Calif.

Missile Battery: A new battery for use in telemetering applications has eighteen 15-amp-hr silver–zinc cells and five 10-amp-hr cells providing discharge voltages of 27 and 6.6 v. Constructed to operate at altitudes of up to 200 miles, and at temperatures ranging from 125 to 0 F, the battery has a shelf life of one year, and a rechargeability of 10 c. It weighs 26 lb. Yardney Electric Corp., 40 Leonard St., New York 13, N.Y.

Vibration Testing: This electronic vibration system—rated at 175,000-VA output and full shaker output of 25,000-lb force—is being delivered to Boeing Aircraft for testing large specimens and complete assemblies. The four-cubicle assembly measures 18 ft long, 5 ft deep, and 6 ft high. A supervisory panel shows operating sequence patterns and locates operational faults. Ling Electronics, Inc., Culver City, Calif.

STORABILITY

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DIMAZINE has many characteristics that make it excel as a storable fuel.

Its remarkable stability has been proven in tests of more than two years' duration, even in mild-steel vessels. Its high thermal stability and low freezing point permit wide variations of storage temperatures. It is not shock sensitive and is unaffected by many types of accidental contamination. It is highly compatible with most metals and appropriate sealant materials.

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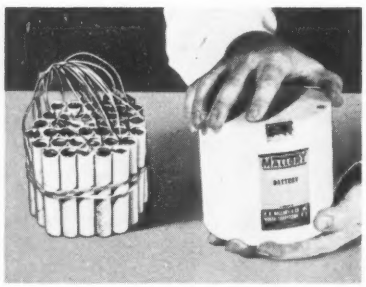
Westvaco Chlor-Alkali Division

General Sales Offices:
161 E. 42nd STREET, NEW YORK 17

Silicon Bridge Rectifiers: Weighing $^1/_4$ oz each, subminiature rectifiers in a new series measure 0.875 by 0.719 by 0.750 in. They operate in missile, airborne, and ground system circuitry at temperatures up to 165 C. Bridge rectifiers are available with ratings from 50 to 500 PIV, with DC output currents up to 0.8 amp. International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.

Satellite Battery: The power unit for the transmitting equipment of the "Cloud Cover" satellite is this cluster

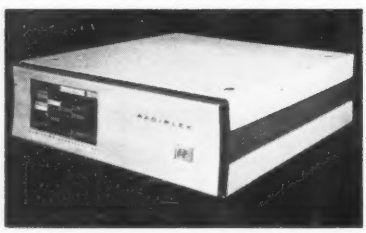


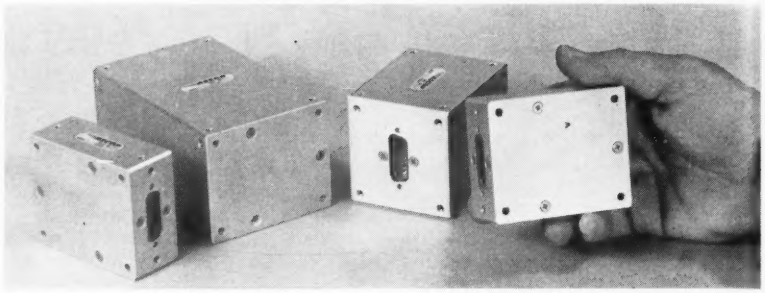
of batteries with a multiprong plug, all potted in Eccafoam. The complete electronic and battery component, designed to transmit a constant tracking signal as the satellite orbits at 18,000 mph, weighs 13 lb. Mallory Battery Co., 13000 Athens Ave., Lakewood 7, Ohio.

Elapsed Time Indicator: With a diameter smaller than a dime, a microminiature timepiece indicates up to 1000 hr for aircraft and missile studies. Elgin-Micronics Div., Elgin National Watch Co., Elgin, Ill.

Transistorized Recorder: Model 400 X-Y recorder consists of a basic plotter with separate input modules for general purpose, computer low-level-differential, time-base, curve-following, and other specialized functions. Improvements include faster slewing speeds, 0.05 per cent internal calibration, 10 microvolt sensitivity, internal Zener diode reference, front panel gain control, and calibrated scales on both ends. Electro Instruments, Inc., 3540 Aero Court, San Diego 11, Calif.

Electronic Decoding: Decoders are designed to take the binary coded parallel information directly to the input of a beam switching tube and display the equivalent decimal information on a Nixie in-line indicator tube.

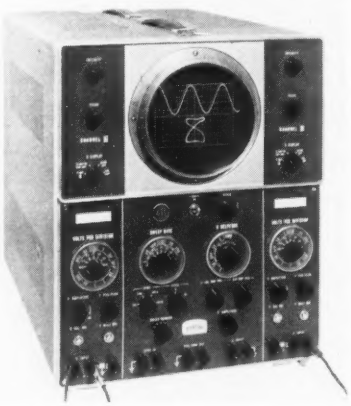




Modular Telemetering: K-series transistorized airborne or ground-based telemetering modules—commutators, low level amplifiers, pulse-width keyers, power supplies, and custom variations of these—have a standard dimension of $3^1/_8$ by $2^1/_2$ in. with length increments of $^5/_8$ in. for multiplexing and coding data in pulse-width form in missiles and space vehicles. Applied Science Corp. of Princeton, P.O. Box 44, Princeton, N.J.

The tube combination performs the decoding with few components, and gives access time in the order of 1 microsec. Electronic Tube Div., Burroughs Corp., Box 1226, Plainfield, N.J.

Dual Beam Oscilloscope: A switching arrangement on the front panel of the Type 411 oscilloscope develops nine modes of display. By introducing z-axis modulation, 27 additional



useful display modes are possible. The sensitive oscilloscope is capable of displaying x-y plots and simultaneously displaying either the x- or y-signal against time. Allen B. DuMont Labs, Inc., 750 Bloomfield Ave., Clifton, N.J.

Low-Loss Coaxial Cable: The cable has a 50-ohm characteristic impedance and 300 to 500 C environmental capabilities. The outer conductor is solid to meet the requirements of attenuation, shielding effectiveness, and temperature range. The cables are semiflexible, and can be safely operated for extended periods at elevated temperatures. Instrument Div., Thomas A. Edison Industries, McGraw-Edison Co., W. Orange, N.J.

Laminated Plastics: Primarily for printed circuits, a flame resistant laminated plastic (Phenolite, grade XXXP-475) exceeds all NEMA required values. The plastic is self-extinguishing and prevents the spread of flame. Thicknesses range from $^1/_{32}$ to $^1/_4$ in.; sheet sizes, 39 by 47 in. and 39 in. sq. National Vulcanized Fibre Co., 1059 Beech St., Wilmington 99, Del.

Miniature Coupling: Series 1010 coupling is 2.5 in. long and weighs slightly over $^1/_2$ oz. Connection is by bayonet-type lock and is self-sealing with O-rings. Coupling is switchable for electronic cooling systems, test stand, filling and charging connections pressure sensing, and other aircraft and missile applications with operating pressures up to 1500 psi. Aeroquip Corp., Jackson, Mich.

Electronic Commutator: A high level unit has a full-scale input of ± 10 v with a resolution of ± 2 millivolts. A low level model provides a full-scale input of ± 10 millivolts with a resolution of ± 10 microvolts. Both have a 50-channel capacity and a 24-kc sampling rate. Radiation, Inc., P. O. Box 37, Melbourne, Fla.

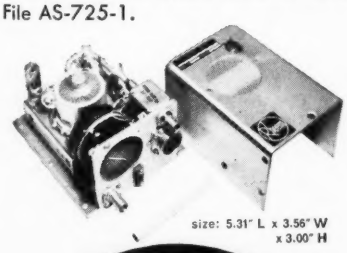
Mercury Battery: A microminiature mercury battery, the RM-312, is only 0.30 in. in diam and 0.125 in. high, fitting the dimensional requirements of the military micromodule program. Energy life, 36 milliamphr at discharge rate of 2 milliamp at 1.22 v. The cell has the usual feature of flat discharge, and voltage remains constant. Mallory Battery Co., 13000 Athens, Ave., Cleveland, Ohio.

Waveguide Switch: Designed for X-band, the Delta switches by remote control a single waveguide input to either of two outputs. Rf power rating equals associated waveguide. Switching time, 0.007 sec; weight, 0.37 lb. Don-Lan Electronics Co., Santa Monica, Calif.

LOUD, CLEAR SIGNAL FROM 1760 MILES...

in the 215 mc to 260 mc telemetering band

THE MODEL REL-10 R-F POWER AMPLIFIER, with outputs from 10 to 100 watts, dramatically increases the range of missile and aircraft telemetering systems . . . teams up with presently available FM transmitters... withstands adverse space environments as demonstrated during the full range of the 1760-mile Thor shot; as part of the 75,000-mile Lunar Probe; and on the Atlas Project Score satellite. For full specs, write for Data File AS-725-1.



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NEW MINIATURE R-F AMPLIFIER

for telemetering in the 215 to 260 mc band

THE MODEL REL-08 is a ruggedized, versatile R-F power amplifier that utilizes a basic design proven in current missile systems. New features include: reduction in cubic size to half that of previous models . . . one tuning control to cover entire expanded frequency range . . . use of ceramic power triode for output of 10 to 15 watts with 1.5 to 2 watts of drive. For full specs, write for Data File AS-728-1.

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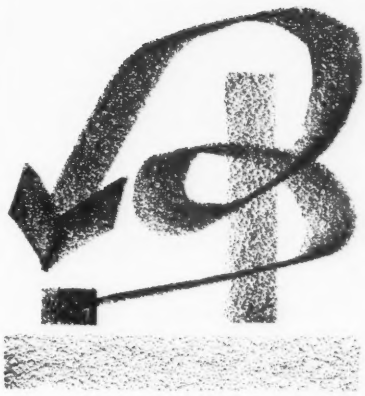
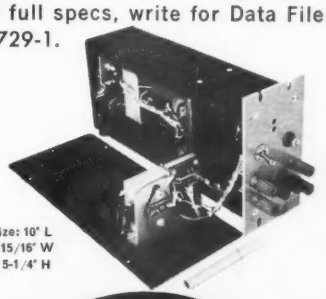


NEW DRIVER AMPLIFIER

impedance transformation without insertion loss

THE REL-122 is a balanced input, balanced output amplifier with a gain of 1 ±0.50. The amplifier is essentially an impedance transformation device without any insertion loss. Frequency response is flat from dc to 1 megacycle. The unit is completely transistorized and has a self-contained power supply. Six units can be mounted into a standard rack panel. Output: ¼ w. For full specs, write for Data File AS-729-1.



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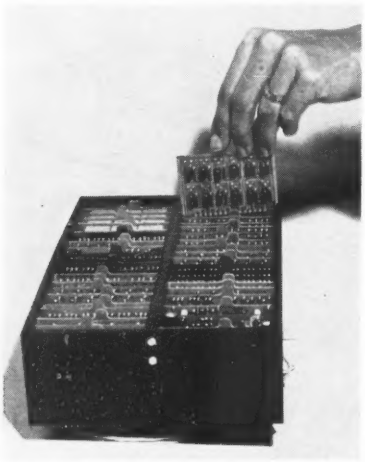
Analog-to-Digital Converter: Model CG 591 solid-state converter weighs 7 lb. Applications include guidance and stability of satellites, missiles,



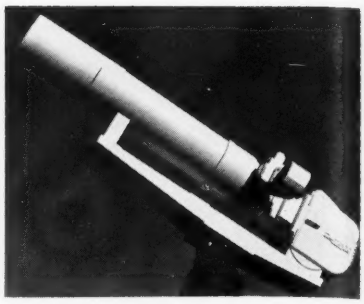
drones, and balloons, as well as measurements in ground installations for data acquisition and reduction systems. Modular construction provides a high order of system flexibility. Gulton Industries, Inc., 212 Durham Ave., Metuchen, N.J.

Cartridge-Type Heater Unit: Used in missile engines to heat lox-oxygen pump lubricant, Tico cartridge heater No. 1926 measures 0.250 in. in diam by 1.5 in. long. The heating element is within 1 in. of the inserted end; the casing is stainless steel. Specifications: 37 w; 28 v; cold resistance, 20 ohms. The unit may also be used in high altitude instrument and hydraulic temperature control. Tektron Instrument Co., P.O. Box 4215, Town & Country, Sacramento, Calif.

Automatic Core Handler: A 1-ft-square automatic core handler, Model 4012, operates at a maximum handling rate of 3600 cores per hour and provides for the separation of the tested cores in five different grades. The control unit operates from a 115 v, 50–60 cps line. The cores are fed from a vibrating reservoir under the influence of a magnetic field. Rese Engineering, Inc., 731 Arch St., Philadelphia 6, Pa.

High Speed 16MM Camera: Fastax Model WF-3T camera, has a high-index glass two-sided prism shutter and a drive mechanism permitting record of action from 150 to 6000 fps. Pictures can be projected at 16 fps. The camera takes 100-ft daylight loading spools. Wollensak Optical Co., 850 Hudson Ave., Rochester 21, N.Y.

Sequence Camera Mount: Fixed focus and focusing versions of the 40-in. f/8.0 Cyclotar lens have been mounted on Hulcher rapid-sequence cameras.



Special features of the mount are a CG-balanced cradle with $^3/_8$-in. tripod insert and a white enamel finish to provide temperature compensations for use in direct sunlight. Gordon Enterprises, North Hollywood, Calif.

Automatic Scanning TV Mount: The mount circles from side to side in a back and forth action, panning the TV camera over an adjustable sector. A single control panel, up to 3000 ft away, commands scanning action. Kin Tel Div., Cohu Electronics, Inc., 5725 Kearny Villa Rd., San Diego 12, Calif.

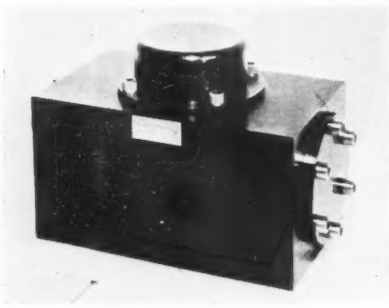
New Explosion Test Chamber: Designed to perform tests under MIL-E-5272A and MIL-E-005272B, for products operating in an explosive atmosphere, a new test chamber can simulate altitudes up to 85,000 ft. Safety features include a quick acting chamber door, which seals the full explosive force and controls an interlock switch to insure door closure before the firing circuit can be energized. Missimers, Inc., 3206 Los Feliz Blvd., Los Angeles 39, Calif.

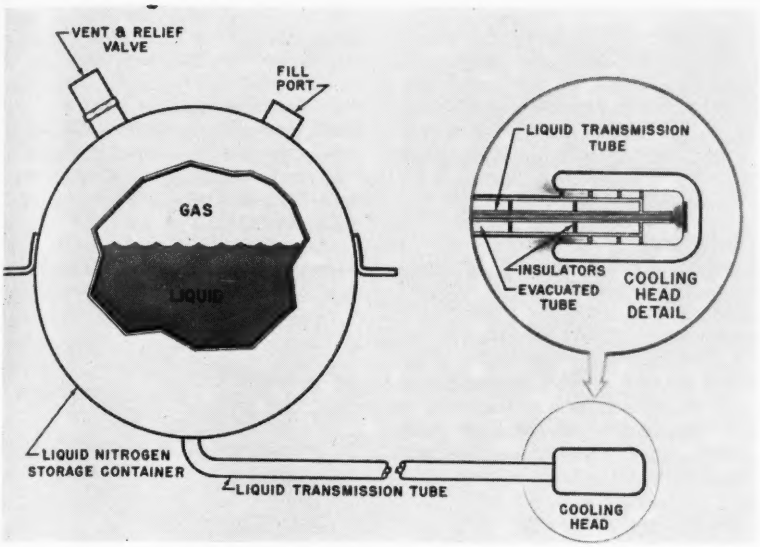
Airborne Receiver Rack: Type ATR-100 airborne receiver rack contains four crystal-controlled phase-lock telemetry receivers, operating in the frequency range of 215–260 mc, and a spectrum-display unit and crystal-storage drawer. Receivers are of the double-superheterodyne type with a noise figure below 8 db. Nems-Clarke Co., Div. of Vitro Corp. of America, 919 Jesup-Blair Dr., Silver Spring, Md.

Erosion Rate Instrument: A material erosion rate instrument (MERI) continuously measures the thickness of any material under flight conditions or in the laboratory. Its output is in the form of an electrical signal which can be recorded on magnetic tape or telemetered to a remote receiver. Erosion of re-entry bodies, rocket nozzles, and radomes can be studied under environments in which it is otherwise difficult to obtain data. Era Engineering, Inc., 1009 Montana Ave., Santa Monica, Calif.

Servovalves Control 200-Ton Space Radio Antenna

The 85-ft-diam dish antenna of the NASA tracking station near Goldstone Dry Lake, Calif., is aimed and rotated with the aid of four Atchley hydraulic servovalves, which drive the positioning mechanism under automatic control. Because the antenna transmits and receives in a narrow beam, its movement must be precise to hunt, track, and communicate with space vehicles at ranges that may reach four billion miles. Two 50-hp servovalves (shown) slue the dish in hunting a target with unknown position. Two smaller servos adjust the dish in tracking a distant vehicle. The servovalves are produced by Raymond Atchley Inc., 2340 Sawtelle Blvd., Los Angeles, Calif.



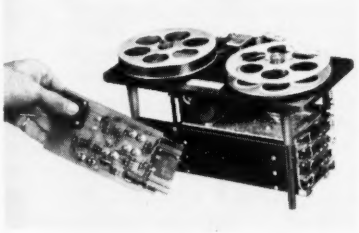


Cryostat Cooling Units: Two types of cryostat systems have been designed to improve the sensitivity and spectral response of IR-detector units on missiles by cooling active semiconductor elements. One system (shown) uses low pressure liquid nitrogen and the other uses high pressure nitrogen gas. The Garrett Corp., 9851 Sepulveda Blvd., Los Angeles 45, Calif.

Surface Temperature Measurement: A hand instrument for making ± 2 per cent full-scale temperature measurements comes automatically compensated for ambient temperatures or noncompensated for relative temperature readings. Model DTF (compensated) has ranges of 0–300, 0–450, 0–650 F; model ETF has a range of 0–200 C. Ultimate response is attained in 3 to 10 sec. Royco Instruments, Inc., Palo Alto, Calif.

Mass Flow Totalizer: A digital inertial-mass-flow measurement system for high pressure nitrogen, oxygen, air, helium, and other gases displays measurements in totalized mass flow or mass flow rate, or both. Range covered is 0.07 to 7 lb/sec at pressures up to 6000 psig over a temperature range of −100 to 250 F, with an overall accuracy of ± 2 per cent of total reading. Inertial Instruments, Inc., 1738 Colorado Ave., Santa Monica, Calif.

Miniature Tape Recorder: Weighing only 5 lb, the TT-100 tape recorder measures 12 by 6 by 8 in. Features include tape speed from 0.5 to $1^7/_8$ ips, up to 60 hr recording, ability to withstand 10-g vibration and 30-g shock, 6-v d.c. battery operation, and tape speed accuracy up to 1.1 per cent. Precision Instrument Co., 1011 Commercial St., San Carlos, Calif.



Multiplier-Divider: A precision analog computing component with long term stability, the Model K-5 multiplier-divider handles inputs and outputs between ± 50 v. A three-digit decade provides an adjustable voltage which may be added to numerator, denominator, or output, and which serves as an adjustable scale factor for operations involving only two variables. Geo. A. Philbrick Researchers, Inc., 285 Columbus Ave., Boston 16, Mass.

Data Card Punch Coupler: The DY-2512 coupler transfers staircase decimal data of the form produced by electronic counters to the 10-line input circuits of the IBM Model 523 summary card punch. Used in conjunction with the DY-2513 counter scanner, the instrument permits card processing of data derived from several simultaneously operating counters. Dymec, Inc., 395 Page Mill Rd., Palo Alto, Calif.

Data Counter Scanner: The DY-2513 scanner operates from staircase voltages produced by electronic counters, transferring the information displayed on each counter to a single digital recorder. The instrument automatically records preset decimal information manually selected by six decimal dials on the front panel. Dymec, Inc., 395 Page Mill Rd., Palo Alto, Calif.

Portable Terminal Pull Tester: Tensile strength of electrical connections can be determined by use of a portable air-actuated tester built around a direct reading force gauge. The terminal to be tested is inserted in a notch in the gauge turret head, which accepts wire sizes up to No. 12 primary cable and up to No. 10 heavy duty cable. The gauge dial holds the force reading at failure of the sample. Hunter Co., 1 Spring Ave., Lansdale, Pa.

Transistorized Tachometer: Transi-Tach is available in three basic models—for 19 in. rack panel mounting, as a portable unit, or with remote indicator, all self-powered by a 9-v battery. It can also be used with 115-v, 60-cycle a.c. The device indicates the speed of a rotating shaft through the use of a magnetic or other speed pickup. Speeds up to 60,000 rps can be read on the large meter scale. Kahn and Co., 547 Windsor St., Hartford 1, Conn.

Film Processor: Gilco 70-mm-film processor handles 100-ft rolls of black and white or color film. Operated from 115-v a.c. power or by hand, it keeps 48 ft of the film exposed to agitated chemicals. The device may be used without a darkroom, and the reel assembly has legs which allow the processor to operate out of the tank for required light exposure in color film developing. Chas A. Hulcher Co., Inc., 911 G St., Hampton, Va.

Contour Measurement: Three-dimension cams up to 3 in. radius and 6 in. long can be inspected on the Precisionaire measuring machine, which uses bench space 32 by 26 in. Irregular shaped parts can also be inspected. Radial and axial movements can be made to an accuracy of 0.000010, and angular position to within ± 6 sec of arc throughout 360 deg. The Sheffield Corp., Dayton, Ohio.

Tape Programmer: MLPR-13, a 13-channel tape programmer, has storage capacity of up to 160 ft of 35-mm Mylar tape, giving a duration of 10.6 min at a transport speed of 3 ips. A sensing device reads pulses thought slots punched in the tape. Operating from 115-v, 400-cycle current, the unit, housed in a metal case 8 by 5 by 3 in., weighs less than 5 lb. Beattie-Coleman, Inc., 1000 N. Olive St., Anaheim, Calif.

Amplifier Klystron: An air-cooled, 1-kw 4-cavity klystron, VA-802, can

be continuously tuned from 1700 to 2400 mc, focused with a permanent magnet. Performance characteristics: Power gain, 40 to 50 db; power output into flat line, 1000 w; RF drive power, 0.1 w (max); typical efficiency, 40 per cent; beam current, 500 milliamp. Dimensions, 18 by 12 by 5 in. Varian Associates, 611 Hansen Way, Palo Alto, Calif.

Microwave Tubes: Type 6280 Planar Triode tubes have found important use as oscillator and low noise amplifier applications in microwave communications equipment. The tubes operate in the 4000 to 5000-mc range. The acorn-sized tube is gold plated for high Q operation, and has a gain of 9 db minimum at 50-mw output. Allen B. DuMont Laboratories, Inc., 750 Bloomfield Ave., Clifton, N.J.

Mercury Switch: A low angle mercury switch (AS603AI) was designed to meet the requirements of vertical gyros, stable platforms, and guidance systems. It weighs only 3.8 grams with three 7-in. Teflon-insulated leads. Contact arrangement is single-pole, double-throw. Switch is rated for 0.255 amp (max), 30 v a.c., and 400 cps for an inductive load. Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

K-Band Magnetron Tube: Fixed frequency K-band magnetron (Type M4154) delivers a minimum peak power output of 20 kw. It can withstand 30-g vibration at 20 to 2000 cps. Cathode strength and high pressure windows contribute to the tubes adaptability to missile uses. Sylvania Electric Products, Inc., Mountain View, Calif.

Crystal Diodes: A new line of subminiature crystal diodes for use in data processing and other electronic applications includes three computer, five gold-bonded, three point-contact, and six silicon-junction types. The diodes have a length of 0.265 in. and a diam of 0.105 in. Sylvania Electric Products, Inc., Woburn, Mass.

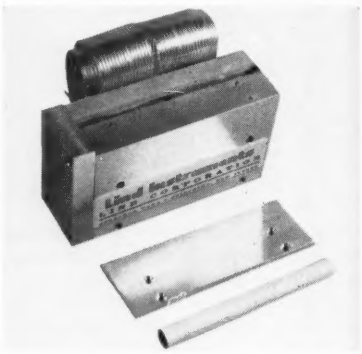
Digital Voltmeter: Model V-34 is a completely transistorized stepping-switch digital voltmeter, automatically measures over the range of ±100 microvolts to ±1000 v. Switches are sealed in oil in interchangeable plug-in containers. A NLS snap-in digital readout permits access for readout lamp service through the front panel without tools. Non-Linear Systems, Inc., Del Mar, Calif.

Synchros and Resolvers: High accuracy pancake synchros and resolvers are available in sizes 20 and 27 for instruments such as inertial guidance systems where space and weight limitations are important. Electrical properties are designed to meet specific applications, and can also be designed to match standard components for accuracy, voltage gradient, and impedances. Luther Mfg. Co., 7312 Varna St., N. Hollywood, Calif.

Coaxial Coupler: Six models, designated 3040 through 3045, comprise a new series of extremely flat coaxial couplers. They cover frequency bands from 240 to 11,000 mc with a nominal coupling value of 20 db. Four models have 10-db values covering 500 to 8000 mc. Primary VSWR is 1.1 to 1.25, and secondary VSWR is 1.2 to 1.3, depending on the model. Narda Microwave Corp., 118 Herricks Rd., Mineola, N.Y.

Missile Umbilical: Integrated into the umbilical are 126 pins (contact size 4 through 20) with leaf spring contacts and two $^1/_2$ in. water-methanol electronic cooling lines for the guidance package. The electrical connector can be submerged in salt water. E. B. Wiggins Oil Tool Co., Inc., 3424 E. Olympic Blvd., Los Angeles 23, Calif.

Telemetering Commutator: A thermocouple and strain-gauge millivolt telemetering commutator samples 3-

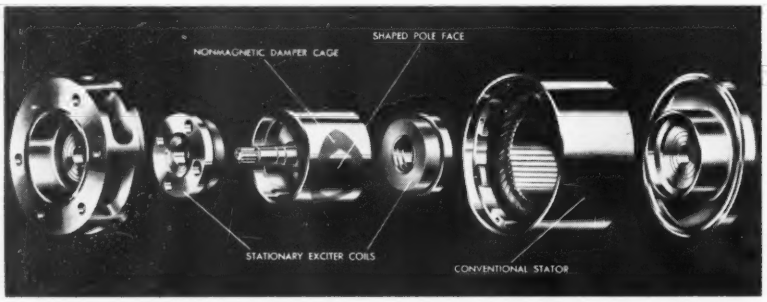


mv signals with $^1/_2$ per cent accuracy. Contact resistance less than 5 ohms. Will operate from 36 to 2500 cps at 25-g vibration, and withstands 150-g shock for 11 millisec. Life at 10 rps in excess of 1000 hr; weight, 12 oz. Lind Corp., Research Park, Princeton, N.J.

Ignition Coil: Developed for small industrial engines, a new ignition coil is wound with extremely small diameter conductors, and the entire unit is impregnated with epoxy plastic. The unit is protected from physical shock, the coil is protected from chemical attack and is impermeable to moisture. Pacific Mercury, 14052 Burbank Blvd., Van Nuys, Calif.

Frequency Sensor: C-400FS1 frequency sensor, operating on 115 v, has 2-w output driving 24-v lamps or relay drives. Green and red readout lamps denote "within tolerance" or "out of tolerance." Several sensors may be connected to a logic circuit in such a way that a single readout will indicate a "no-go" condition if any one of the readings is out of tolerance. Magnetic Circuit Elements, Inc., 3722 Park Place, Montrose, Calif.

Vibration Pickup: Vibramite Type 11 miniature vibration pickup is an eddy current damped unit with a flat response curve over its full range. Acceleration up to 50 g for continuous duty, and up to 100 g intermittently do not damage the unit. Dimensions, 1.42 in. sq. and 1 in. high; weight, 2.75 oz. MB Mfg. Co., P.O. Box 1825, New Haven 8, Conn.



Design for Synchronous Functions: The SECSYH (Stationary-Exciter-Coil Synchronous) design, features a unique magnetic structure combining the advantages of simple brushless construction with the weight and size advantages of conventional statically excited machines. Used as an a.c. generator Secsyn offers long-life reliability, high speed and high temperature operation, and adaptability to special cooling methods. The machine can also be designed to function as a d.c. generator, synchronous motor, constant-speed motor, or as a synchro. Jack & Heintz, Inc., 17600 Broadway, Cleveland 1, Ohio.

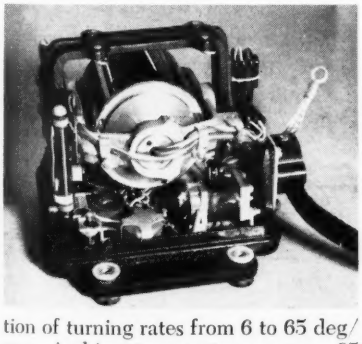
Gold Electroplating: Auro Glo process of electroplating gives gold deposits 5 to 10 times as hard as those from a cyanide bath and 2 to 3 times as hard as those from bright cyanide gold solution. The process permits substituting thinner deposits without impairing performance characteristics. Ductile plating as heavy as 0.008 in. show excellent adhesion to basis metal. Lea-Ronal, Inc., 139–20 109th Ave., Jamaica 35, N.Y.

Infrared Reflector Coating: An improved process for metal-coating IR reflectors to withstand high rotational stresses makes it possible to produce a flat, adherent, nonporous reflector to a higher production rate and at about one-fifth the cost entailed in hard anodizing. The Singer Mfg. Co., Military Products Div., 149 Broadway, New York 6, N.Y.

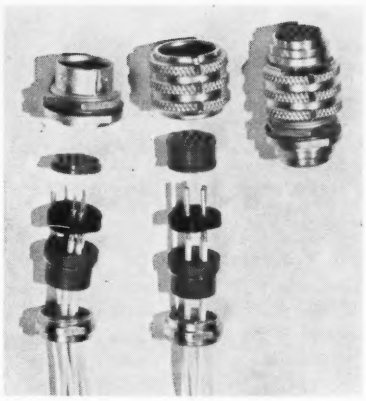
Gas Flowmeter: Using the principles of the Pottermeter turbine-type flowmeter, a new gas meter measures flow for nuclear, industrial, and rocket and missile applications over a wide temperature range. This data can be converted to mass flow rate or SCFM by applying standard electronic computing instruments or direct density sensors. Potter Co., Div. of Potter Aeronautical Co., Union, N.J.

Disconnect Couplers: Heavy-duty oxygen and liquid oxygen and liquid nitrogen quick-disconnect couplers are available in tube sizes $^1/_2$, $^3/_4$, 1, and $1^1/_2$ in. They are made of stainless steel, chromeplated in wear areas, and operate at pressures up to 500 psi, with proof pressure of 1000 psi. The coupler has a slip-joint that disconnects with negligible break-away force. The Bruning Co., Lincoln, Nebr.

Rate Gyroscope: The GG79 rate gyroscope—for indicating or controlling attitude rate of change for missiles—weighs 1.7 lb and occupies a cube measuring about 3.5 in. It has selec-



tion of turning rates from 6 to 65 deg/sec. Ambient temperature range, −65 to 165 F; potentiometer resistance range, 420 to 15,000 ohms; threshold, 0.1 deg/sec or less; powder load, 45 w starting and 20 running. Minneapolis-Honeywell Regulator Co., Aeronautical Div., Minneapolis, Minn.



Miniature Electrical Connectors: New DS snap-in miniature electrical connectors feature insertable contacts, silicone inserts, and crimped terminations replacing solder pots. The connectors give continuous dielectric separation without voids. The mated connectors withstand temperatures from −100 to 300 F, have minimum contact retention of 25 lb. The Deutsch Co., 7000 Avalon Blvd., Los Angeles 3, Calif.

Camera Digital Recorder: Incorporated in a 35-mm motion picture camera, a new Magnavox recording device provides a 96-bit matrix image on each frame, and correlates coded data with pictorial records in real time. The device was developed for application in engineering tests, missile tracking, reconnaissance, flight tests, and microfilm document recording. At 80 fps the camera can record 7680 bits of coded data per second. Traid Corp., 17136 Ventura Blvd., Encino, Calif.

Differential Switch: A small switch has been developed to sense displacement of two shafts. In operation, a desired shaft position is set into the 0.25-in. shaft and related to a 0.125-in. shaft by a set of single-pole, double-throw center-off contacts. A printed-circuit commentator disk and rotatable brushes make contacts. The Newton Co., 55 Elm St., Manchester, Conn.

Liquid Fluorine Pump: Transfer of liquid fluorine, usually handled by gas pressurization, can now be done with a throttle valve and a pump supported by a tankage pressurization system and shutoff valve. The pump delivers 1000 gpm at a pressure rise of 150 psi. It is driven by a 150 hp induction motor at 3250 rpm. Aerojet-General Corp., Azusa, Calif.

PRODUCT LITERATURE

Effects of High Aromatic Fuels on Elastomers. Thiokol Chemical Corp., 780 N. Clinton Ave., Trenton, N.J.

Pet Solid Propellant Rocket Motor. Atlantic Research Corp., Alexandria, Va.

Rocket Fuel Control. Systems Div., Consolidated Electrodynamics, 300 N. Sierra Madre Villa, Pasadena, Calif.

Kodak 16mm, 35mm, and 70mm Films. Special Sensitized Products, Sales Div., Eastman Kodak Co., Rochester 4, N.Y.

Super-Farron F/0.87 for Dim-Light Photography. Farrand Optical Co., Inc., Bronx, Blvd. & East 238 St., New York 70, N.Y.

Making the Decision to Automate Engineering Drawings. Office Systems & Service Dept., Westinghouse Electric Corp., East Pittsburgh Div., E. Pittsburgh, Pa.

Interchangeable Typewriter Type. Remington Rand, Div. of Sperry Rand Corp., 315 Fourth Ave., New York 10, N.Y.

Liquefied Gas Containers. Linde Co., Div. of Union Carbide Corp., 30 E. 42 St., New York 17, N.Y.

Industrial Television Camera. Kintel, A Div. of Cohu Electronics, Inc., Box 623, San Diego 12, Calif.

MicroSadic High Speed Digital Processor. Systems Div., Consolidated Electrodynamics, 300 N. Sierra Madre Villa, Pasadena, Calif.

Video Band Magnetic Recorder/Reproducer. Mincom Div., Minnesota Mining and Mfg. Co., 2049 S. Barrington Ave., Los Angeles 25, Calif.

Altitude Simulation Chambers. General Vacuum Corp., 400 Border St., E. Boston 28, Mass.

Varipulse Shock Machine. Barry Controls Inc., 700 Pleasant St., Watertown 72, Mass.

2-Gyro Master Reference. Lear, Grand Rapids Div., 110 Ionia Ave., N.W., Grand Rapids 2, Mich.

Aviation Clamps. Wittek Mfg. Co., 4305–37 W. 24 Place, Chicago 23, Ill.

High Temperature Steels and Alloys Data Card. Advertising Dept., Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh 22, Pa.

Air Hardening Dynaflex. Latrobe Steel Co., Latrobe, Pa.

High Strength Aluminum Casting Alloy Tens-50. NaVan Products, Inc., International Airport, Los Angeles 45, Calif.

Machining Aluminum. Reynolds Metals Co., Richmond 18, Va.

Heavy Press Extrusions. Harvey Aluminum, 19200 S. Western Ave., Torrance, Calif.

Optical Products. Bausch & Lomb Optical Co., Rochester 2, N.Y.

Flotation. U.S. Hoffman Machinery Corp., Industrial Filtration Div., Thompson Rd. Plant #1, Syracuse, N.Y.

Titanium Report. Harvey Aluminum, 19200 S. Western Ave., Torrance, Calif.

Plastic Mastic. Williamson Adhesives, Inc., 8220 Kimball Ave., Skokie, Ill.

Aluminum Mill Products. Reynolds Metals Co., Richmond 18, Va.

Industrial Demineralizers. Penfield Mfg. Co., Inc., 19 High School Ave., Meriden, Conn.

Missile Components, Atomic Structures. Research Welding & Engineering Co., Inc., 18201 S. Santa Fe Ave., Compton, Calif.

Condensed Catalog of Rotary Components. Kearfott Co., Inc., Little Falls, N.J.

Aircraft Hanger Heating. L. J. Wing Mfg. Co., Div. of Aero Supply Mfg. Co. Inc., 140 Vreeland Mills Rd., Linden, N.J.

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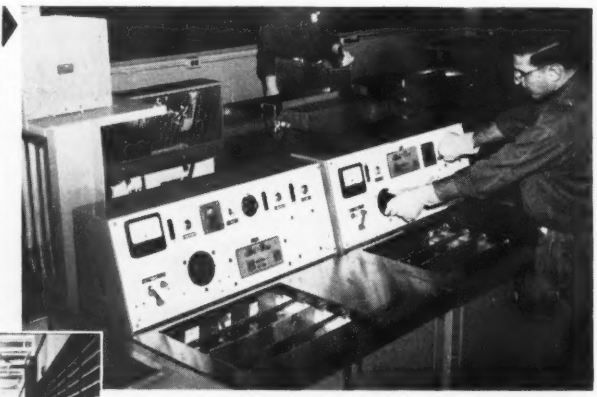
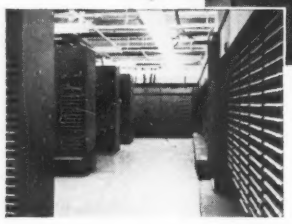
Model 8933: Face spray ring acts simultaneously with eye-wash, sending controlled streams of water from specially designed twin fountain heads.

These JET PLATERS are used to gold-plate some of the printed wiring boards for the SAGE Computer — as well as for experimental IBM equipment currently under development.

Heart of our SAGE System is the 275 ton IBM Computer. Shown here are some of the computer frames containing pluggable electronic units which perform data processing to solve air-defense problems.





IBM SAGE COMPUTER CIRCUITRY PLATED WITH SEL-REX BRIGHT GOLD

The 275 ton computer pictured, in part, above has 7,300 pluggable units containing printed card assemblies. To help maintain the "built in" reliability for which I B M is famous the world over, these assemblies were plated with Sel-Rex Bright Gold Process. The precision-plating required by this application was done in four JET PLATERS—complete precious metal plating facilities in a single compact cabinet.

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Plasticote Wires and Cables. Chester Cable Corp., Chester, N.Y.

Miniature Coaxial Cable. The Rex Corp. Hayward Rd., West Acton, Mass.

Circuit Breakers. Wood Electric Co., 244 Broad St., Lynn, Mass.

VOR/LOC/MBR Navcom Module. Lear, Inc., Learcal Div., 2171 S. Bundy, Santa Monica, Calif.

Single-Turn, $1^3/_4$-in. Diam Precision Potentiometers. Helipot Div. of Beckman Instruments, Inc., Fullerton, Calif.

Digital Voltmeters. Non-Linear Systems, Inc., Del Mar, Calif.

Silicon and Selenium Rectifiers and Diodes. International Rectifier Corp., El Segundo, Calif.

Selenium Photovoltaic Cells. International Rectifier Corp., El Segundo, Calif.

Ultrasensitive Micro Volt-Ammeter. Keithley Instruments, Inc., 12415 Enclid Ave., Cleveland 6, Ohio.

Sensitive Pressure Transducers. BJ Electronics, Borg-Warner Corp., 3300 Newport Blvd., Santa Ana, Calif.

Cold Cathode Vacuum Gauge. Miller Laboratories, 18 Raymond St., Latham, N.Y.

Calibration System. Technique Associates Inc., 1413 N. Cornell Ave., Indianapolis 2, Ind.

Automatic Telemetry Data Reduction Systems. Epsco, Inc., Systems Div., 588 Commonwealth Ave., Boston, Mass.

PM Silvercel Battery. Yardney Electric Corp., 40 Leonard St., New York 13, N.Y.

Liquid Temperature Sensing Thermostats. Vapor Heating Corp., 80 E. Jackson Blvd., Chicago 4, Ill.

Radicorder. Radiation Inc., P.O. Box 37, Melbourne, Fla.

Medical Electronics. Gulton Industries, Inc., Vibro-Ceramics Div., 212 Durham Ave., Metuchen, N.J.

Strip Chart Recorder with Continuous Integration. Minneapolis-Honeywell Regulator Co., Industrial Div., Philadelphia 44, Pa.

Manometers, Theory and Application. Dynametrics Corp., Northwest Industrial Park, Burlington, Mass.

Servomanometers. Exactel Instrument Co., 5545 Eva Ave., Los Altos, Calif.

Manometers. Trimount Instrument Co., 3119 W. Lake St., Chicago 12, Ill.

Compound High Vacuum Pumps. F. J. Stokes Corp., Philadelphia 20, Pa.

Automatic, Recording Vacuum Thermo-Balance. American Instrument Co., 8030 Georgia Ave., Silver Spring, Md.

Temperature Probes and Pressure Transducers. Rosemount Engineering Co., 4900 W. 78 St., Minneapolis 24, Minn.

Aero Valves. Specialty Engineering Co., 264 W. Fairview, San Gabriel, Calif.

Fine Pitch Precision Stock Gears. U.S. Gear Corp., Wakefield, Mass.

Barksdale Valve Catalog 59–60. Control Valve Div., Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.

MS Variable-Speed Pulleys. T. B. Wood's Sons Co., Chambersburg, Pa.

Dehydration for Gases, Valves for Gases and Liquids. Robbins Aviation Inc., 2350 E. 38 St., Los Anglees 58, Calif.

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August 31—September 5, 1959

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Church House, Dean's Yard, Westminster, London, where Congress sessions will be held

Houses of Parliament and Westminster Bridge, London

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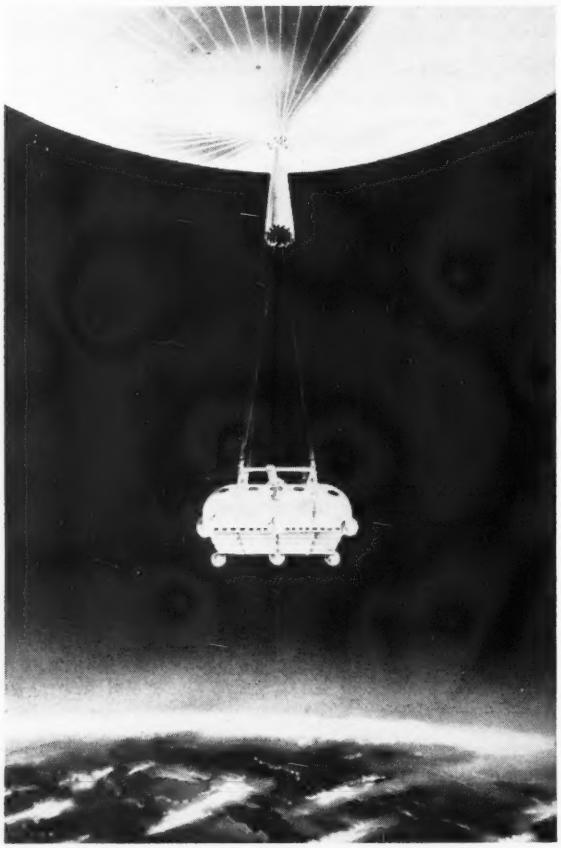

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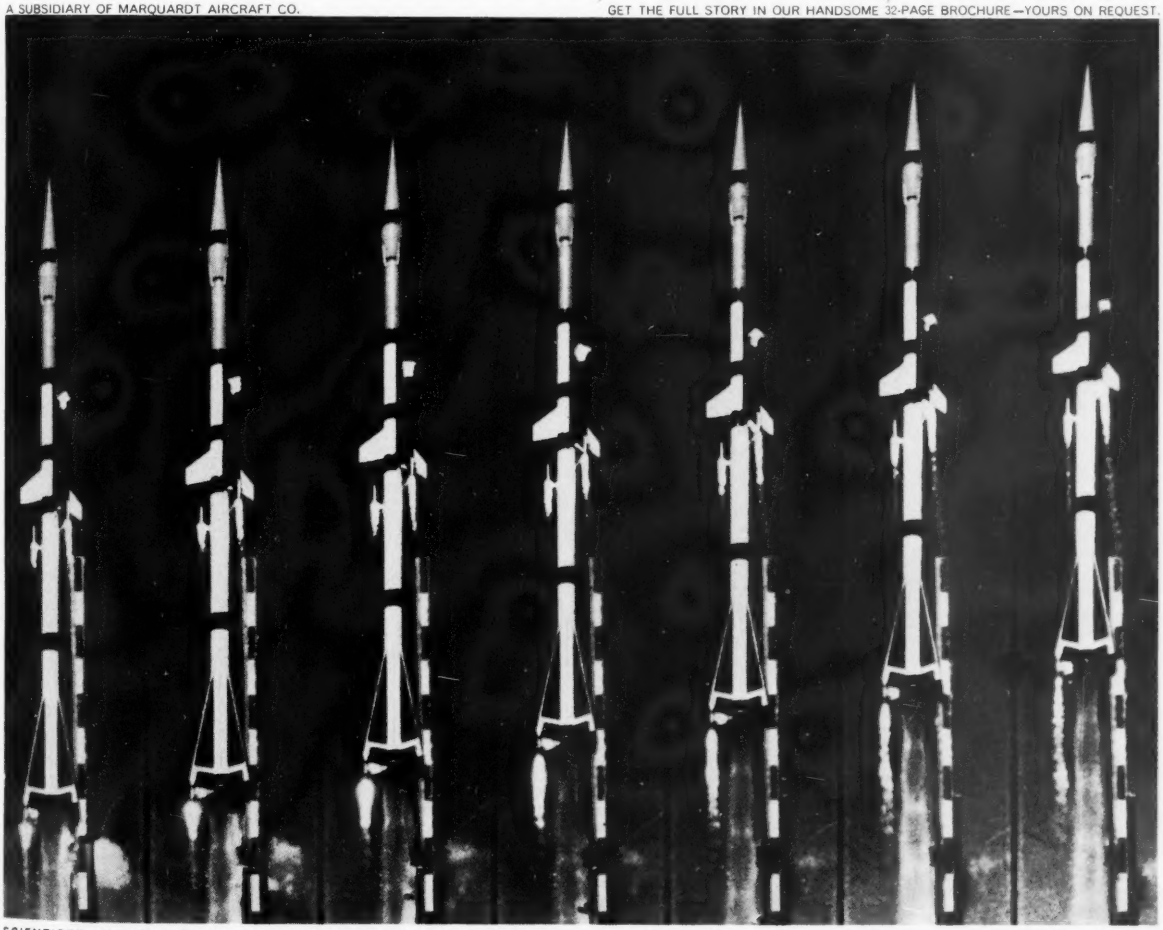

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